
En

JOURNAL

OF THE

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS,

INCLUDING

ORIGINAL COMMUNICATIONS ON TELEGRAPHY AND ELECTRICAL SCIENCE.

PUBLISHED UNDER THE SUPERVISION OF THE EDITING COMMITTEE,

AND EDITED BY

W. E. AYRTON, F.R.S., THE CHAIRMAN.

VOL. XI.—1882.

London:

E. AND F. N. SPON, 46, CHARING CROSS.

New York:

44, MURRAY STREET.

1882.

29031

TABLE OF CONTENTS.

Vol. XI.

cl

THE SOCIETY

OF

TELEGRAPH ENGINEERS

AND OF

ELECTRICIANS.

ESTABLISHED 1871.

LIST OF OFFICERS AND MEMBERS.

Corrected to April 22nd, 1882.

NOTICE.

It is particularly requested that any change of Residence or Address may be communicated at once to the Secretary.

THE SOCIETY OF

Telegraph Engineers and of Electricians.

COUNCIL.—1882.

President.

LIEUT.-COL. C. E. WEBBER, R.E.

Past-Presidents.

CHARLES WILLIAM SIEMENS, F.R.S., D.C.L.—1872 and 1878.
FRANK IVES SCUDAMORE, C.B.—1873.
SIR WILLIAM THOMSON, LL.D., F.R.S.—1874.
LATIMER CLARK, M. Inst. C.E.—1875.
C. V. WALKER, F.R.S.—1876.
PROFESSOR ABEL, C.B., F.R.S.—1877.
LIEUT.-COL. J. U. BATEMAN-CHAMPAIN, R.E.—1879.
W. H. PREECE, F.R.S., M. Inst. C.E.—1880.
PROFESSOR G. C. FOSTER, F.R.S.—1881.

Vice-Presidents.

WILLOUGHBY SMITH.
PROFESSOR W. G. ADAMS, F.R.S.
C. E. SPAGNOLETTI, M. Inst. C.E.
PROFESSOR D. E. HUGHES, F.R.S.

Members.

W. S. ANDREWS.
WILLIAM T. ANSELL.
SIR CHARLES BRIGHT, M. Inst. C.E.
E. B. BRIGHT.
THE EARL OF CRAWFORD AND BALCARRES, F.R.S.
H. G. ERICHSEN.
H. C. FORDE, M. Inst. C.E.
MATTHEW GRAY.
JOHN FLETCHER MOULTON, F.R.S.
ALEXANDER SIEMENS.
AUGUSTUS STROH.
C. F. VARLEY, F.R.S.

Associates.

CAPTAIN J. T. BUCKNILL, R.E.
T. RUSSELL CRAMPTON, M. Inst. C.E.
CHARLES H. B. PATEY.

OFFICERS.

Auditors.

J. WAGSTAFF BLUNDELL, 12, Delahay Street, Westminster, S.W.
FREDERICK C. DANVERS (India Office).

Hon. Treasurer.—EDWARD GRAVES.

Hon. Secretary.—LIEUT.-COL. FRANK BOLTON.

Hon. Solicitors.

Messrs. WILSON, BRISTOWS & CARPMAEL, 1, Copthall Buildings, E.C.

Chairman of the Editing Committee.—PROF. W. E. AYRTON, F.R.S.

Librarian.—ALFRED J. FROST.

Secretary.—F. H. WEBB.

Bankers.

Messrs. COCKS, BIDDULPH & Co., 43, Charing Cross, S.W.

Library and Offices of the Society.

4, The Sanctuary, Westminster, S.W.

LOCAL HONORARY SECRETARIES AND TREASURERS.

JAMES ALLEN, Telegraph Superintendent Great Southern Railway, Buenos Ayres	ARGENTINE & ORIENTAL DEL URUGUAY REPUBLICS.
DON JOSÉ APARICIO, Representative of the Direct Spanish Telegraph Company, Calle de Fernando VI., Numᵒ 1., Madrid	SPAIN.
JOHN AYLMER, Civil Engineer, 4, Rue de Naples, Paris	FRANCE.
J. M. COLLETTE, Engineer of the Netherlands Telegraphs, The Hague	The NETHERLANDS.
E. C. CRACKNELL, Superintendent of Telegraphs, Sydney	NEW SOUTH WALES.
JAMES DAKERS, Manager, Montreal Telegraph Company, Montreal	CANADA.
Le Commandeur E. D'AMICO, Director-General of the Italian Telegraphs, Rome	ITALY.
FRÉDÉRIC DELARGE, Engineer of the Belgian Telegraphs, Brussels	BELGIUM.
N. ISPOLATOFF, Director of Telegraphs, St. Petersburg	RUSSIA.
CHARLES LEMON, Ph.D. Superintendent of Telegraphs, Wellington	NEW ZEALAND.
C. L. MADSEN, 49, Norre, Sogade, Copenhagen	DENMARK.
SAMUEL W. MCGOWAN, Chief Inspector of Telegraphs and Postal Service, Melbourne	VICTORIA.
C. NIELSEN, Director-General of the Norwegian Telegraphs, Christiania	NORWAY.
J. R. PREECE, Indo-European Government Telegraphs, Shiraz	PERSIA.
E. ROSENBUSCH, A.M.Ins.C.E. Mediterranean Extension Telegraph Company, Valetta, Malta	MALTA AND THE MEDITERRANEAN.
Dr. WERNER SIEMENS, 94, Markgrafen Strasse, Berlin	GERMANY.
JAMES SIVEWRIGHT, M.A., C.M.G., General Manager of Telegraphs, Cape of Good Hope	The CAPE AND SOUTH AFRICA.
F. G. TEALE (Acting Local Hon. Sec. and Treasr.), Indian Government Telegraphs, Calcutta	INDIA.
CHARLES TODD, C.M.G., Director-General, South Australian Telegraphs, Adelaide	SOUTH AUSTRALIA.
G. G. WARD, Gen. Superintendent of the Direct United States Cable Company, 16, Broad Street, New York	NORTH AMERICA.
WILLIAM WARREN, Superintendent in Tasmania of the Eastern Extension, Australasia, and China Telegraph Company, George Town.	TASMANIA.

SOCIETY OF

Telegraph Engineers and of Electricians.

LIST OF MEMBERS,

CORRECTED UP TO APRIL 22ND, 1882.

† *Members who have served as Vice-Presidents.*
* *Members who have served on the Council.*

HONORARY MEMBERS.

SIR GEORGE BIDDEL AIRY, K.C.B., D.C.L., LL.D., *late Astronomer-Royal.*	The White House, Crooms Hill, Greenwich, S.E.
AD. COCHERY	Minister of Posts and Telegraphs, 101, Rue de Grenelle, Paris.
GENERAL SIR EDWARD SABINE, R.A., K.C.B., D.C.L., LL.D.	13, Ashley Place, Westminster, S.W.
FRANK IVES SCUDAMORE, C.B. . (*Past President.*)	British Post Office, Constantinople.
PROFESSOR WILHELM WEBER, F.R.S.	Göttingen.

Total Number of Honorary Members 5

FOREIGN MEMBERS.

ALONSO PRADOS, Don JULIAN . .	Director of Spanish Telegraphs, Madrid.
ALTENECK, F. VON HEFNER . .	94, Markgrafen Strasse, Berlin.
AMIOT, GUSTAVE	French Government Telegraph Department, Toulon.
APARICIO, DON JOSÉ . . (*Honorary Secretary for Spain*).	Representative of the Direct Spanish Telegraph Company, Calle de Fernando VI., Numo. 1, Madrid.
ARANTAVE, Don ENRIQUE DE . .	P.O. Box 170, New York.
ARISZ, L.	Divisional Inspector of Netherlands Telegraphs, Utrecht.

Atkins, George W. E.	Western Union Telegraph Co., 197, Broadway, New York.
Bachelor, Charles	Menlo Park, New Jersey, U.S.A.
Baldwin, William D.	25, Grant Place, Washington, D.C., U.S.A.
Banneux, Joseph	Belgian State Telegraph Department, Brussels.
Baron, H.	103, Rue de Grenelle, Paris.
Battle, Don José	Inspector-General of Telegraphs, Philippine Islands.
Bayol, Paul	l'Ecole Supérieure de télegraphie, 103, Rue de Grenelle.
Bedemann, Mons. de	97, Avenue de Villiers, Paris.
Bejar, Don Alejandro, de	Director of Spanish Telegraphs, Carthagena, Spain.
Bergon, Louis M.	103, Rue de Grenelle, Paris.
Blavier, Edouard	103, Rue de Grenelle, Paris.
Bolton, Marco Antonio	Cia del Telegrafo, Trasandino, Valparaiso, Chili.
Bontemps, Charles	103, Rue de Grenelle, Paris.
Boomsma, A.	The Netherlands State Telegraph Office, Edam, Holland.
Bourne, C.	
Boyle, R. K.	63, Fulton Street, New York, U.S.A.
Braam, John A., de	27, Place de la Madeleine, Paris.
Brandão, Dr. M. N.	Engenheiro Geral das Linhas do Norte, Rio de Janeiro, Brazil.
Breguet, Antoine	Scientific Instrument Maker, 4, Rue Perrault, Paris.
Bréguet, M., Sen.	39, Quai de l'Horloge, Paris.
Brieve, C.	Divisional Inspector of Netherlands Telegraphs, Roosendaal.
Brindisi, L.	Direction des Télégraphes Helleniques, Athens.
Brix, Dr. Philipp W.	Engineer, Imperial Telegraphs, Berlin.
Brooks, David	22, South Twenty-first Street, Philadelphia, U.S.A.
Campos da Paz, M. V.	18, Montague Place, Russell Square, W.C.
Capanema, Professor Dr.	Director-General of the Brazilian Telegraphs, Rio de Janeiro.
Carème, Felix	103, Rue de Grenelle, Paris.

CARDARELLI, FEDELE . .	. Ispettore Telegrafico, Florence, Italy.
COLLETTE, J. M. . . *(Honorary Secretary for the Netherlands.)*	. Engineer of the Netherlands Telegraphs, The Hague.
COMERMA, Captain ANDRÉS A. .	. 82, Mortimer Street, Cavendish Square, W.
COROMINA, Don VICENTE .	. Director of Spanish Telegraphs, Madrid.
COURTENAY, L. W. . . .	. 45, Rue Cambon, Paris.
CUELI, GAVINO R. . . .	. Ferro Carril de Buenos Ayres y Compana, Estacion Compana, Buenos Ayres.
D'AMICO, M. le Commandeur E. *(Honorary Secretary for Italy.)*	. Director-General of the Italian Telegraphs, Rome.
DEHMS, Dr. FR. . . .	. Imperial Telegraphs, Constanz, Baden.
DELAFIELD, A. FLOYD . .	. Noroton, Connecticut, U.S.A.
DE LA PRECILLA, ENRIQUE .	. 364, Florida, Buenos Ayres.
DELARGE, FRÉDÉRIC . *(Honorary Secretary for Belgium.)*	. Engineer of the Belgian Telegraphs, Brussels.
DE LA TOUANNE, G. . .	. 103, Rue de Grenelle, Paris.
D'INFREVILLE, GEORGE . .	. Western Union Telegraph Company, 197, Broadway, New York.
DWIGHT, H. P. . . .	. General Superintendent, Montreal Telegraph Company, Toronto.
ECKERT, Gen. THOMAS T. . .	. General Manager, Western Union Telegraph Company, 197, Broadway, New York, U.S.A.
EDISON, THOMAS A. . .	. Menlo Park, New Jersey, U.S.A.
ELDIK, R. K. VAN . . .	. Divisional Inspector of Netherlands Telegraphs, Venlo, The Netherlands.
EVERS, I. C. . . .	. Inspector of Railway Telegraphs, Utrecht, The Netherlands.
FARMER, Professor MOSES G. .	. U.S. Torpedo Station, Newport, R.I.
FORTUN Y VARONA, Don EUGENIO	. International Ocean Telegraph Company, Havanah, Cuba.
FRAYSSINIER, J. . . .	. 97, Boulevard Sébastopol, Paris.
FREEMAN, FRANK L. . .	. United States Patent Office, Washington, D.C., U.S.A.
FRÖHLICH, Dr. OSCAR . .	. 94, Markgrafen Strasse, Berlin.
GALANTE, Don JOSÉ . .	. Inspector of Spanish Telegraphs, Government Department, Seville.

Garay, Don Felix	"Poste Restante," à Paris.
Gotendorf, Silvanus	39, Rue de Clichy, Paris.
Gower, Frederic A.	Gower-Bell Telephone Company, 9, Great Winchester Street Buildings, E.C.
Grace, G. H.	Superintendent of Telegraphs, Central R.R. of N.J., Easton, Pa., U.S.A.
Gramaccini, Jules H. F.	Government Telegraph Department, Marseilles.
Gray, Elisha	Highland Park, Illinois, U.S.A.
Guillbaume, F. C.	Cologne, Rhenish Prussia.
Hamilton, George A.	Western Union Telegraph Company, 197, Broadway, New York, U.S.A.
Hasselt, A. van	Dutch East Indian Telegraphs, Batavia.
Hauff, P. P.	460, Pacific Street, Brooklyn, New York, U.S.A.
Heinrichs, Charles F.	164, Quai de Jemmapes, Paris.
Helland, George T.	Great Northern Telegraph Company, Shanghai.
Hellings, M. L.	International Ocean Telegraph Company, Key West, Florida, U.S.A.
Henningsen, Jacob	Great Northern Telegraph Company, Foochow, China.
Hequet, A.	103, Rue de Grenelle, Paris.
Holst, F. I. C. M.	Great Northern Telegraph Company, Hong Kong.
Honcke, Captain Heinrich	Danish Royal Engineers, Copenhagen.
Hosklær, Colonel V.	Danish Royal Engineers, Copenhagen.
Hospitalier, Edouard	23, Rue d'Arcole, Paris.
Islas Bustamante, Don Saturnino	Ferro Carril Mexicano, City of Mexico, Mexico.
ISPOLATOFF, NICHOLAUS (*Honorary Secretary for Russia.*)	Director of St. Petersburg Telegraphs, St. Petersburg.
Iturriaga, Don Enrique	Director of Spanish Telegraphs, Barquillo, 17, Madrid.
Jablochkoff, Paul	31, Rue d'Offermont, Paris.
Jager, T. de	Divisional Inspector of Netherlands Telegraphs, Leeuwarden, The Netherlands.

JÖHNKE, Captain	Royal Danish Navy, Copenhagen.
JOHNSON, EDWARD H. . . .	Edison's Electric Light Company, No. 65, Fifth Avenue, New York, U.S.A.
JONES, F. W.	Union Electric Manufacturing Company, 7 & 9, Bond Street, New York, U.S.A.
JONES, L. BIGELOW . . .	Electrician to the Amoskeag Manufacturing Company, Manchester, New Hampshire, U.S.A.
KELLOGG, MILO G.	220, East Kinzie Street, Chicago, U.S.A.
KOLVIG, F.	Great Northern Telegraph Company, Nagasaki.
LACOINE, EMILE	Director of Telegraphs, Constantinople.
LADD, GEORGE S.	President of the Gold and Stock Telegraph Company, San Francisco.
LAGARDE, JOSEPH	103, Rue de Grenelle, Paris.
LASARD, Dr. ADOLPHE . . .	German Union Telegraph Company, Werder Strasse, Berlin.
LAURITZEN, S.	Great Northern Telegraph Company, Copenhagen.
LEMOS BASTO, J. M. DE . . .	18, Montague Place, Russell Square, W.C.
LOBIT Don LUIS	Sub-Director of Spanish Telegraphs, Madrid.
LOCKWOOD, T. D.	American Bell Telephone Company, 95, Milk Street, Boston, Mass., U.S.A.
LOPEZ DE OCHOA, Don ANTONIO . .	Inspector-General of Spanish Telegraphs, Madrid.
LORENTZEN, VALDEMAR . . .	Royal Danish Telegraphs, Copenhagen.
LÜDERS, His Excellency Gen. Von .	Director-General of the Imperial Russian Telegraphs, St. Petersburg.
MADSEN, C. L. . . . . . (*Honorary Secretary for Denmark.*)	49, Norre Sogade, Copenhagen.
MARTIAL, A. DE SAINT . . .	Secretary of the International Bureau, Berne.
MAYNARD, G. C.	1413, G. Street, Washington, U.S.
MENIER, HENRI	7, Rue du Theatre, Grenelle, Paris.
MERCADIER, E.	103, Rue de Grenelle, Paris.
MEYER, B.	No. 1, Boulevard St. Denis, Paris.
MÖLLER, C. A.	Great Northern Telegraph Company, Nystad (Finland).
MONCEL, Count THEODORE DU . .	7, Rue de Hambourg, Paris.

MONNIER, D. . . .	. 57, Rue Pigalle, Paris.
MOORE, GEORGE W. . .	. Via Orefici 2, Milan, Italy.
MORA, Don FRANCISCO . .	. Inspector of Spanish Telegraphs, Government Department, Madrid.
MORA, Don ORESTES DE . .	. Director of Spanish Telegraphs, Government Department, Barcelona.
MULVAD, CARL . . .	. Royal Danish Telegraphs, Copenhagen
NAGEL, J. H. . . .	. Netherlands State Telegraph Office, Arnhem.
NAVARRA, W. S. . . .	. Telegraph Department, Teheran, Persia.
NIAUDET, ALFRED . . .	. 6, Rue de Seine, Paris.
NIELSEN, C. . . . (*Honorary Secretary for Norway.*)	. Director-General of the Norwegian Telegraphs, Christiania.
NIELSEN, F. C. C. . . .	. Great Northern Telegraph Company, Copenhagen.
ORDUNA, Don CARLOS DE . .	. Rollo 2, Madrid.
ORDUNA, Don EMILIO . .	. Sub-Director of Spanish Telegraphs, Madrid.
ORTIZ, Don CRISTOBAL . .	. Telegrafos del Gobierno Federal, City of Mexico, Mexico.
PELLEGRINO, Commander ENRICO	. Italian Telegraphs, Rome.
PETERSON, E. B. . . .	. Great Northern Telegraph Company, Copenhagen.
PETERSEN, J. A. P. . .	. Great Northern Telegraph Company, Mariehamn, Aland.
PFORDEN, FREDERICK VON DES .	. Eastern Extension Telegraph Company, Batavia.
PISSAREWSKY, NICOLAS . .	. 18, Rue Znamenskaia, St. Petersburg.
POPE, FRANK L. . . .	. Elizabeth, New Jersey, U.S.A.
PRESCOTT, GEORGE B. . .	. "The Berkeley," No. 20, Fifth Avenue, New York, N.Y., U.S.A.
RAE, THOMAS W. . . .	. 239, Broadway, New York, U.S.A.
RAU, EDOUARD . . .	. 26, Boulevard de l'Observatoire, Brussels.
RAYMOND, L. . . .	. 103, Rue de Grenelle, Paris.
RAYNAUD, JULES . . .	. 103, Rue de Grenelle, Paris.

REDONET, Don José de . . .	Director of Spanish Telegraphs, Santander, Spain.
RENTZCH, Fred. John . . .	Eastern Extension Telegraph Company, Banjoewangie, Java.
REPSOLD, J. G.	
ROTHEN, Timotheus . . .	Engineer-in-Chief of the Swiss Telegraphs, Berne.
ROUSSEAU, A. J.	Care of G. F. Rogers, 5, Great Winchester Street Buildings, E.C.
RUSSELL, Thorwold F. . . .	Great Northern Telegraph Company.
SANTMAN, L. J.	Inspector of Dutch-Indian Government Telegraphs, Batavia.
SARGENT, W. D.	General Superintendent, The Telephone Company, 1111, Chestnut Street, Philadelphia, Pa., U.S.A.
SALVATORI, Commander Fedele .	Italian Telegraphs, Rome.
SCHÄFFLER, Otto	7, Halbgasse, No. 26, Vienna.
SCHULTZ, C. A.	Great Northern Telegraph Company, Shanghai.
SELIGMANN-LUI, Gustave P. . .	23, Rue Denfert-Rochereau, Paris.
SEVERN, Henry A. . . .	Care of Messrs. H. S. King & Co., 65, Cornhill, E.C.
SIEMENS, Dr. WERNER . . (*Honorary Secretary for Germany.*)	94, Markgrafen Strasse, Berlin.
SOLDAN, Don Carlos Paz . .	Lima, Peru.
SONNE, Carl C.	Great Northern Telegraph Company, Shanghai.
SPANG, H. W.	Reading, Pennsylvania, U.S.A.
STARING, William . . .	Director of the Netherlands Telegraphs, The Hague.
STEARNS, J. B.	43, Gordon Square, W.C.
STRAUBE, Otto	Telegraph Engineer, No. 787, Calle Cangallo, Buenos Ayres.
SUENSON, Albert	Great Northern Telegraph Company, Hong-Kong, China.
SUENSON, Capt. Edward . . .	Great Northern Telegraph Company, Copenhagen.
SUMMERS, C. H.	Western Union Telegraph Company, Chicago, Illinois, U.S.A.
SWINYARD, Thomas . . .	Managing Director, Dominion Telegraph Company, Toronto, Canada.
TESSIER, Jules	7, Rue du Theatre, Grenelle, Paris.

TOBLER, Dr. ADOLPH . . .	Federal Polytechnic School, Zürich.
TRANT, LAWRENCE B. . . .	Provincial Telegraph Department, 108, Calle Cangallo, Buenos Ayres.
UCELAY, Don PASCUAL . . .	Director of Spanish Telegraphs, Zaragoza.
UGARTE, OLEGARIO V. . . .	Inspector-General de los Telegrafos Nacionales, Buenos Ayres.
VALLEJOS, HIGINIO, Lieut.-Col. . .	General Manager, Military Telegraphs, Buenos Ayres.
VAZQUEZ, Don FRANCISCO . .	Sub-Director of Spanish Telegraphs Madrid.
VIALE, Commander CLEMENTE . .	Italian Telegraphs, Rome.
VIANISI, Le Marquis L. . . .	Messina.
VINCHENT, JULIEN . . .	Inspector-General of the Belgian Public Works, Brussels.
VOGEL, CARL	94, Markgrafen Strasse, Berlin.
WALKER, PHILIP	3, Rue Scribe, Paris.
WILLOT, JOSEPH	57, Rue de Boulainvilliers, Paris-Passy.
WISSE, W. J.	Sub-Director of the Government Telegraph Office, The Hague.
WUNSCHENDORFF, JULES H. . .	97, Rue de Rennes, Paris.
ZETZSCHE, Professor Dr. K. E. . .	N. Weissenburger Strasse, 27, Berlin.

Total Number of Foreign Members . . 170.

MEMBERS.

ABEL, PROFESSOR, C.B., F.R.S. (*Past President.*)	Royal Arsenal, Woolwich.
ADAMS, PROFESSOR, W.G., F.R.S. (*Vice-President.*)	43, Notting Hill Square, W.
ADAMS, M. R.	Indian Government Telegraphs.
AHERN, JOHN	The Edison Telephone Co., 15, Cross Street, Manchester.
ALLEN, JAMES (*Honorary Secretary for the Argentine and Oriental del Uruguay Republics.*)	Telegraph Superintendent, Great Southern Railway, Buenos Ayres.
ANDERSON, Sir JAMES	66, Old Broad Street, E.C.
ANDERSON, RICHARD, F.C.S.	44, Essex Street, Strand, W.C.
ANDREWS, THOMAS	Anglo-American Telegraph Company, Brest.
ANDREWS, TOM B.	
ANDREWS, W. S. (*Member of Council.*)	Manager, Indo-European Telegraph Company, 18, Old Broad Street, E.C.
ANSELL, WILLIAM T. (*Member of Council.*)	66, Old Broad Street, E.C.
* ARMSTONG, R. Y., Major, R.E.	Brompton Barracks, Chatham.
ATKINSON, Dr. E., F.C.S.	Portesbury Hill, Camberley, Surrey.
AYLMER, JOHN, Civil Engineer (*Honorary Secretary for France.*)	4, Rue de Naples, Paris.
AYRTON, PROFESSOR W. E., F.R.S. (*Chairman of the Editing Committee.*)	68, Sloane Street, S.W.
* BAILEY, JOHN	India Rubber, Gutta Percha, and Telegraph Works Co., Silvertown, E.
* BARLOW, WILLIAM HENRY, F.R.S.	2, Old Palace Yard, S.W.
BATEMAN-CHAMPAIN, J.U., LT.-COLONEL, R.E. (*Past President.*)	49 and 50, Parliament Street, S.W.
BEEMAN, JOSEPH S.	182, Earl's Court Road, Kensington, W.
BELL, ALFRED D.	Waihemo, Otago, New Zealand.
* BELL, ANDREW	Postal Telegraphs, Gloucester Road, N.W.
BELL, Professor A. G.	Office of the National Bell Telephone Company, 95, Milk Street Boston, Mass., U.S.A.
BENNETT, ALFRED ROSLING	267, Sauchiehall Street, Glasgow.
BERESFORD, CHARLES F. C., Capt., R.E.	7th Field Company R.E., Natal, South Africa.
BETTS, A. S.	Kurrachee.
BETTS, J. A.	Tient Sin, China.

Biggs, C. H. W.	7, Freeland Road, Bromley, Kent.
Binney, W. P.	Eastern Telegraph Company, Syra, Greece.
Bird, Edward C.	Indian Government Telegraphs, Bombay.
Bishop, James Draper	Shanghai.
Blissett, T.	(Indian Government Telegraphs, Calcutta) care of Messrs. Grindlay & Co., 55, Parliament Street, S.W.
Bohr, Heinrick G. C.	Great Northern Telegraph Company, Shanghai.
Bold, E. H.	Napier, New Zealand.
BOLTON, FRANK, Lt.-Colonel (*Honorary Secretary.*)	4, The Sanctuary, Westminster, S.W.
* Bourdeaux, John	Submarine Telegraph Company, Dover.
Boteler, R.	Indian Government Telegraphs, Calcutta.
Boyle, R. Vicars, C.S.I., M. Inst. C.E.	Care of Grindlay & Co., 55, Parliament Street, S.W.
Briggs, James A.	Indian Government Telegraphs, Jabalpur, Central Provinces, East Indies.
BRIGHT, Sir CHARLES, M. Inst. C.E. (*Member of Council.*)	31, Golden Square, W.
BRIGHT, EDWARD B. (*Member of Council.*)	31, Golden Square, W.
BRISTOW, G. L. (*Honorary Solicitor.*)	1, Copthall Buildings, E.C.
Brittle, John Richard	"Farad Villa," Green Lane, Westcombe Park, Blackheath.
Broadbent, J. E., Capt., R.E.	Simla, Punjab, India.
Brooke, William R.	(Indian Government Telegraphs, Bombay), care of Messrs. King & Co., 65, Cornhill, E.C.
Brown, E. O.	Royal Arsenal, Woolwich, S.E.
Browne, W. J.	Indian Government Telegraphs.
Buller, Ernest W.	49, Charlotte Road, Birmingham.
Burke, J.	Indian Government Telegraphs.
Bury, Viscount, K.C.M.G.	65, Princes Gate, W.
Canning, Sir Samuel, C.E.	7, Great Winchester Street Buildings, Old Broad Street, E.C.
Cappel, Albert J. L.	(Deputy-Director-General of Indian Government Telegraphs), care of Messrs. Grindlay & Co., 55, Parliament Street, S.W.
* Cardew, Philip, Lieut., R.E.	School of Military Engineering, Chatham.

Cargill, W. W., F.R.G.S.	Lancaster Lodge, Campden Road, Kensington, W.
Carmichael, Sir Jas., Bart.	Submarine Telegraph Company, Threadneedle Street, E.C.
Carson, William, M. Inst. C.E.	Whitecross Wire & Iron Co., Warrington, Lancashire.
Cecil, Lord Sackville	The Oast House, Hayes Common, Beckenham, Kent.
Chambre, Alan E.	Camera Lodge, South Norwood, S.E.
Charles, G. G.	Indian Government Telegraphs, Calcutta.
* Chauvin, George von	Care of Messrs. Siemens Bros. & Co., 12, Queen Anne's Gate, Westminster, S.W.
Clark, Edwin, M. Inst. C.E.	6, Westminster Chambers, Westminster, S.W.
CLARK, LATIMER, M. Inst. C.E. *(Past President.)*	6, Westminster Chambers, Westminster, S.W.
Clark, T. S.	Lancashire and Cheshire Telephonic Exchange, 38, Faulkner Street, Manchester.
Collett, Richard	19, St. Mary's Road, Harlesden, Middlesex.
Common, A. A., F.R.A.S.	63, Eaton Rise, Ealing, W.
Cooke, Conrad W.	5, Westminster Chambers, Victoria Street, S.W.
Cowper, E. A., M. Inst. C.E.	6, Great George Street, Westminster, S.W.
Cox-Walker, E.	Messrs. Harrison, Cox-Walker, & Co., Electricians, Darlington.
CRACKNELL, E. C. *(Honorary Secretary for New South Wales).*	Superintendent of Telegraphs, Sydney, Australia.
Cracknell, W. J.	
† CRAWFORD AND BALCARRES, Earl of, F.R.S. *(Member of Council).*	47, Brook Street, W.
Criswick, George S., F.R.A.S.	Royal Observatory, Greenwich.
Cromartie, D. B.	Indian Government Telegraphs, Calcutta.
* Crompton, R. E.	4, Mansion House Buildings, E.C.
Crookes, William, F.R.S.	7, Kensington Park Gardens, W.
Crossley, Louis J.	Moorside, Halifax, Yorkshire.
Crossman, Col. William, R.E., C.M.G.	War Office, Whitehall.
Culbertson, Dr. J. N.	
† Culley, R. S., M.I.C.E.	Saint Martin's, Weston-super-Mare.
Curtoys, Charles	Old Charlton, Kent.
Cushing, Thos., F.R.A.S.	India Store Depôt, Belvedere Road, Lambeth, S.E.

DAKERS, JAMES (*Honorary Secretary for Canada*).	Montreal Telegraph Company, Montreal, Canada.
DANIELL, FRANCIS T. B.	Indo-European Telegraphs, Teheran, Persia.
DARLING, W. C.	Indian Government Telegraphs.
DAVIDS, R. G. B.	Estrada de Ferro Companhia Paulista, Campestina, Brazil.
DAVIES, WILLIAM H.	Eastern Telegraph Company, Zanzibar
DE LA RUE, WARREN, M.A., D.C.L., F.R.S.	73, Portland Place, W.
DE MARSAC, F. R.	(Indian Government Telegraphs) care of H. J. Brown, Esq., 7, King's Bench Walk, Temple, E.C.
DERING, GEORGE E.	Lockleys, Welwyn, Herts.
DE SAUTY, C. V.	Eastern Telegraph Company, Gibraltar.
DESPOINTES, F.	Submarine Telegraph Company, Threadneedle Street.
DEWAR, Professor, F.R.S.	Royal Institution, Albemarle Street, W.
DONOVAN, H. C.	Enderby's Wharf, East Greenwich, S.E.
DOUGLAS, C., General, R.A.	India.
DOUGLAS, J. C.	Indian Government Telegraphs.
DOYLE, JAMES D.	Victorian Railways, Melbourne, Victoria, Australia.
DRESING, CHRISTIAN	Great Northern Telegraph Company, 119, Bishopsgate Street Within, E.C.
DUFFIN, C.	Indian Government Telegraphs.
DUTHY, J. W. B.	Indian Government Telegraphs.
EDMUNDS, H., Jun.	Heath Villas, Halifax, Yorkshire.
EDWARDS, J. R.	Postal Telegraphs, Liverpool.
EGGINGTON, ALFRED	Eastern Telegraph Company, Otranto, Italy.
EIDSFORTH, R. P.	St. Paul's Works, 76, Little Britain, E.C.
ELLEBY, JAMES HENRY	Lancashire and Yorkshire Railway Co., Manchester.
ELLERY, ROBERT J. L., F.R.S., F.R.A.S.	Government Astronomer, Melbourne, Victoria, Australia.
ELLIS, WILLIAM, F.R.A.S.	Royal Observatory, Greenwich.
ERICHSEN, H. G. (*Member of Council.*)	119, Bishopsgate Street Within, E.C.
ESTLER, PAUL	Messrs. Siemens' Works, Charlton.
EVANS, MORTIMER, C.E., F.G.S., F.R.A.S.	Engineer to the Wemyss Bay Railway, Wemyss Bay.
FAHIE, J. J.	Indo-European Telegraph Department, Shiraz, Persia.

FFINCH, B. T.	Indo-European Government Telegraphs.
FIELD, S. D.	Stockbridge, Mass., U.S.A.
FITZGERALD, DESMOND G. . .	6, Akerman Road, Brixton, S.W.
FLEMING, PROFESSOR J. A., B.A., D.Sc.	University College, Nottingham.
FLEMING, J. C.	Superintendent Government Telegraphs, Perth, Western Australia.
FLETCHER, J. W. . . .	Telegraph Department, London and North Western Railway, Manchester.
FLINDELL, R. B. . . .	Indian Government Telegraphs.
FLOYD, WILLIAM HENRY . .	Superintendent of Telegraphs, Great Indian Peninsular Railway, Bombay
FORBES, Professor GEORGE, F.R.S.E.	35, Duke Street, St. James's, S.W.
FORDE, H. C., M. Inst. C.E. (*Member of Council.*) .	6, Duke Street, Adelphi, W.C.
FOSTER, A. LE NEVE . . .	East Hill, Wandsworth.
FOSTER, PROFESSOR G.C., F.R.S. (*Past President.*) .	12, Hilldrop Road, N.
FRANCE, J. R.	General Manager, Mexican Telegraph Company, City of Mexico, Mexico.
FRASER, Captain CHARLES . .	Government Telegraph Department, Cape of Good Hope.
FULLER, JOHN	Newcastle Wharf Works, Old Ford Road, Bow, E.
FULLER, JOHN W. . . .	Care of Messrs. Case and Londonsack, 1, James Street, Adelphi, W.C.
FULLER, THOMAS . . .	Brazilian Submarine Telegraph Co., 8, Great Winchester Street, E.C.
FURZE, EDWIN	Compania Telegrafica del Rio de la Plata, Buenos Ayres.
GALTON, Capt. DOUGLAS, C.B., F.R.S.	12, Chester Street, Grosvenor Place, S.W.
GAVEY, JOHN	Postal Telegraphs, Cardiff.
GERHARDI, CHARLES A. . .	106, Cannon Street, E.C.
GILBERT, EDWARD . . .	Dundee and Arbroath Joint Railway, Calcutta Buildings, Commercial Street, Dundee.
GILL, W. J., Captain, R.E. . .	1, Edinburgh Mansions, Victoria Street, S.W.
GISBORNE, FREDERICK N. . .	Government Telegraph Department, Ottawa, Canada.
GLADSTONE, Dr. JOHN HALL, F.R.S. .	17, Pembridge Square, W.
GLOVER, WALTER T. . . .	Moorhurst, Kersal, Manchester.
GODFREY, W. B. . . .	54, Regent's Park Road, N.W.
GOLDSTONE, CHARLES . . .	London and South Western Railway, Southampton.
GORDON, C. B. P. . . .	Indian Government Telegraphs, Calcutta.

Gordon, J. E. H., B.A.	28, Collingham Place, S.W.
Gosselin, G. A.	Indian Government Telegraphs, Colombo, Ceylon (care of Henry S. King & Co., East India Agents, 65, Cornhill).
Gott, D. W.	Eastern Extension Telegraph Company, Port Darwin, South Australia.
Gott, John	French Atlantic Telegraph Company, St. Pierre, Newfoundland.
Grant, Angus	Montreal Telegraph Company, Montreal.
Graves, A.	14, Priory Street, York.
* GRAVES, E. (*Honorary Treasurer.*)	Postal Telegraphs, General Post Office, E.C.
Graves, James	Anglo-American Telegraph Company, Valentia, Ireland.
GRAY, MATTHEW (*Member of Council.*)	Lessness Park, Abbey Wood, Kent.
Gray, Robert K.	Silvertown, E.
Greener, J. H.	14, St. Swithin's Lane, E.C.
Greenhill, Matthew C.	Brighton Grove, Rusholme, Manchester.
Grover, George E., Major, R.E.	Park Hill, Croydon.
Guenzel, Ernst	Indo-European Telegraph Company, Tiflis, Caucasus, Russia.
Guthrie, Frederick, Ph.D., F.R.S.	Royal Normal School of Science, South Kensington, S.W.
Hall, William Henry, Capt., R.N.	H. M. S. "St. Vincent," Gosport.
Halpin, Capt. Robert C.	38, Old Broad Street, E.C.
* Hancock, Walter	10, Upper Chadwell Street, Myddleton Square, E.C.
Hare, G. J.	Indian Government Telegraphs.
Harrison, Richard, Col., R.E., C.B.	United Service Club, Pall Mall, S.W.
Harvey, Fred., Capt., R.N.	1, Sparrows Herne Villas, Bushey Heath, near Watford, Herts.
Harwood, F.	Eastern Telegraph Company, Carcavellos, Lisbon.
Hawkins, Frederick	India Rubber and Gutta Percha Company, Silvertown.
Haynes, Frederick T. Iago	Great Western Railway, Taunton.
Heaviside, A. W.	Postal Telegraphs, Newcastle-on-Tyne.
Hedges, Killingworth	25, Queen Anne's Gate, Westminster, S.W.
Henley, W. T.	Chesterton House, Plaistow, Essex.
Henneberg, Otto	Gneisenau Strasse, 100, S.W., Berlin.
* Higgins, Frederick	Exchange Telegraph Company, 17, Cornhill, E.C.

Hill, A. D.	Indian Government Telegraphs.
Hill, T. C.	Indian Government Telegraphs.
* Hockin, Charles, M A., C.E.	8, Avenue Road, St. John's Wood.
Hoeltzer, C.	Cambridge House, Old Charlton Village, Kent.
Hooper, J. P.	Coventry Park, Streatham.
Hopkinson, Dr. J. H., M.A., F.R.S.	4, Westminster Chambers, Victoria Street, S.W.
Houghton, E.	London Brighton and South Coast Railway Company, London Bridge, S.E.
Houtum-Schindler, General Albert	Inspector-General of Persian Telegraphs, Teheran.
Howe, J.	Brazilian Submarine Telegraph Company, Pernambuco.
HUGHES, Professor, D.E., F.R.S. (*Vice-President.*)	Care of the London Joint Stock Bank, 69, Pall Mall, S.W.
Hurley, Edward Butler	Colombo, Ceylon.
Hutchinson, S. H. C.	Indian Government Telegraphs.
Hyde, H., Major-General, R.E.	India Office, Westminster, S.W.
Irvine, A. H.	Mersey Railway Company, Birkenhead.
Jacob, Frank	2, Oakland Villas, Maryon Road, Charlton, S.E.
James, T. R.	Government Telegraph Department, Melbourne, Australia.
Jamieson, Andrew, C.E.	Principal of the College of Science and Arts, Glasgow.
Jenkin, Fleeming, Professor, F.R.S., M. Inst. C.E.	3, Great Stuart Street, Edinburgh.
Jenkin, John	Office of the Engineer-in-Chief, General Post Office, E.C.
Jervois, Sir W. H., General, R.E., K.C.M.G., C.B.	Government House, Adelaide, South Australia.
Johnson, J. Thewlis	Bradford Iron Works, Manchester.
Johnson, Walter C.	King's Garden, Eltham, Kent.
Johnston, W. P.	Indian Government Telegraphs.
Jones, J. C. D.	Eastern Extension Telegraph Company, Singapore.
Jones, T. J.	12, Princes Street, Hanover Square, W.
Jones, W. C. Nigel	Indian Government Telegraphs.
Judd, Walter	Eastern Extension Telegraph Company, Penang.

KAISER, E. F.	94, Markgrafen Strasse, Berlin.
KEITH, GEORGE, C.E.	Cienfuegos, Cuba (care of the Cuba Submarine Telegraph Company, 61, Old Broad Street, E.C.)
* KEMPE, H. R.	Postal Telegraphs, General Post Office, E.C.
KIESER, W.	Messrs. Elliott Bros., 101, St. Martin's Lane, W.C.
LADD, W.	Beak Street, Regent Street.
LAISTER, JAMES	Postal Telegraphs School, Moorgate Street Buildings, E.C.
LAMBERT, FRANK	7, Pope's Head Alley, Lombard Street, E.C.
LANGDON, WILLIAM	Superintendent, Telegraph Department, Midland Railway, Derby.
LANE, J. H.	Indian Government Telegraphs.
LANE, J. M.	Indian Government Telegraphs, Calcutta.
LARKIN, THOMAS J.	Holly House, 18, Maygrove Road, Kilburn, N.W.
LARKINS, A. B.	Indian Government Telegraphs.
LAUCKERT, EDWARD	99, Maryon Road, New Charlton, S.E.
LAUGHLIN, ROBERT C.	Indian Government Telegraphs.
LAVENDER, JOHN	5, Carter Street, Roman Road, Higher Broughton, Manchester.
LAWS, J. C.	41, St. John's Park, Upper Holloway.
LEMON, C., Ph.D., (*Honorary Secretary for New Zealand.*)	Wellington, New Zealand.
LE MESURIER, F. A., Major, R.E.	Natal, South Africa.
* LOEFFLER, LOUIS	12, Queen Anne's Gate, Westminster, S.W.
LORRAIN, JAMES GRIEVE	2, Victoria Mansions, Westminster, S.W.
LUKE, S. P. W. V., C.I.E.,	Indian Government Telegraphs, Calcutta.
LUND, JOHN A.	41, Cornhill, E.C.
LUNDY, CHARLES	Direct United States Cable Company, Torbay, Nova Scotia.
McGRATH, E. A.	Indian Government Telegraphs.
McLEOD, Professor H.	The Royal Indian Engineering College, Cooper's Hill.
MACKENZIE, JAMES	48, Osnaburgh Street, Regent's Park, N.W

MACLEAN, F. G.	Indian Government Telegraphs, Kurrachee.
MACLEANE, C. J. H. . . .	Indian Government Telegraphs.
MAITLAND, JAMES M.H., Lt.-Col., R.E.	Aldershot.
MAGINNITY, ANDREW T. . .	Telegraph Department, Wellington, New Zealand.
* MALCOLM, E. D., Lieut.-Col., C.B., R.E.	18, Queen's Gate Place, S.W.
MALLOCK, H., Lieut.-Col., B.S.C. .	Indian Government Telegraphs, Simla.
MANCE, H. C.	Indo-European Government Telegraphs, Kurrachee.
MARKS, C. B. D. . . .	Indian Government Telegraphs.
MATHIESON, JAMES . . .	India Rubber Company, Silvertown.
MAYNE, R. C., Admiral, R.N., C.B. .	101, Queen's Gate, Hyde Park, S.W.
McEVOY, Capt. C. A. . . .	18, Adam Street, Adelphi, W.C.
McGOWAN, SAMUEL W. . . (*Honorary Secretary for Victoria.*)	Chief Inspector of Telegraphs and Postal Service, Melbourne, Victoria, Australia.
McGREGOR, WILLIAM . . .	Indian Government Telegraph Department, River View, Dhubri, Lower Assam.
MEDDINGS, W. G. . . .	Inspector of Telegraphs, Christchurch, New Zealand.
MELHUISH, W. F. . . .	Indian Government Telegraphs, Calcutta.
MELVILLE, W. B. . . .	Indian Government Telegraphs.
MITTELHAUSEN, JULIUS . . .	28, Wood Street, Woolwich, S.E.
MOBERLEY, G. J. . . .	Indian Government Telegraphs.
MÖLL, F. H. L.	Indo-European Telegraph Company, 18, Old Broad Street, E.C.
MORGAN, C. G.	
MORRIS, J.	
MOULTON, J. FLETCHER, F.R.S. (*Member of Council.*)	11, King's Bench Walk, Temple, E.C.
* MUIRHEAD, ALEXANDER, D.Sc., F.C.S.	Oakwood, 12, Farquhar Road, Upper Norwood.
MURRAY, K. L.	Victorian Railways, Melbourne, Victoria, Australia.
MURRAY, R., Col., B.S.C. . .	Director-General of the Indian Government Telegraphs, Calcutta.
NAGLO, EMIL	44, Waldemar Strasse, Berlin.
NEALE, JOHN	North Staffordshire Railway, Stoke-upon-Trent.
NELSON, FREDERICK D. . . .	Indo-European Telegraph Company Teheran, Persia.

Newitt, W. T.	Eastern Extension Telegraph Company, Elephant Point, Rangoon.
* Newman, G. G.	2, Holles Street, Cavendish Square.
Nosworthy, William F.	Compañia Telegrafica Submarina, Monte Video.
Obach, Dr. Eugen	Messrs. Siemens Brothers & Company, Charlton, S.E.
O'Kelly, H. M., B.A.	Indian Government Telegraphs, Madras.
Oldham, John	Compania Telegrafica del Rio de la Plata, Monte Video.
Oppenheimer, Joseph	52, Brown Street, Manchester.
Ormiston, Frederick A.	Riverside, Twickenham.
Ovens, J.	Indian Government Telegraphs.
Owen, H. P.	Indian Government Telegraphs (care of Messrs. Henry S. King & Co., 65, Cornhill, E.C.)
Parsone, E. W.	Manager, West Coast of America Telegraph Company, Calle Blanco, Valparaiso.
Paterson, E. J.	St. Paul's Works, 76, Little Britain, E.C.
Peake, J.	(Indian Government Telegraphs), Whitchurch, Salop.
Pell, Bennett	General Manager, Australian and China Telegraph Company, Singapore.
Perry, Professor John	14, Talgarth Road, West Kensington, W.
Phillips, Frederick C.	Victoria Works, Lambeth, S.E.
Phillips, Samuel E., Jun.	Holbrook, Shooter's Hill, Kent.
Pitman, C. E., C.I.E., F.R.G.S.	Indian Government Telegraphs.
* Pitt, St. George Lane Fox	4, Grosvenor Gardens, S.W.
Porritt, T. W.	Compañia Telegrafica Platino-Brazilero, Monte Video.
PREECE, JOHN RICHARD (*Honorary Secretary for Persia.*)	Indo-European Government Telegraphs, Shiraz, Persia.
PREECE, W. H., F.R.S., M. Inst. C.E. (*Past President.*)	Gothic Lodge, Wimbledon.
Pringle, Edward H., F.R.A.S., F.R.G.S.	Public Works Department, Madras.
Radcliffe, Arthur H. W.	5, Carrs Lane, Birmingham.
Radcliffe, James	Telegraph Department, Great Northern Railway, Retford.
Rapieff, John	7, Finsbury Park Road, N.

Rawson, Frederick L. . .	11, Queen Victoria Street, E.C.
Rawson, Herbert, Lieut., R.E. .	5, Clifton Terrace, Monkstown, Dublin.
Reade, A. J. M. . . .	(Indian Government Telegraphs) St. Katherine's, Anerley Road, Upper Norwood, S.E.
Reid, James	12, Wharf Road, City Road, N.
Reynolds, Charles . . .	Indian Government Telegraphs, Calcutta.
Rhodes, E. F., Lieut., R.E. . .	
Riddle, Edward . . .	21, Woodlands Villas, Blackheath, S.E.
Risch, Gustav	Belvedere Cottage, Lansdowne Road, Old Charlton, S.E.
Rogers, R. W. S., Lieut., R.N. .	H.M.S. "Vernon," Portsmouth.
ROSENBUSCH, EDWARD . . (*Honorary Secretary for Malta and the Mediterranean.*)	Mediterranean Extension Telegraph Company, Valetta, Malta.
Rücker, Professor Arthur W., M.A.	The Yorkshire College, Leeds.
Rutherford, J. M. . . .	District Traffic Superintendent, Rajputana State Railway, Ajmere.
* Sabine, Robert, C.E. . . .	Grosmont House, Hampton Wick.
Sach, Henry	Great Eastern Railway, Liverpool Street Station, E.C.
Salomons, Sir David, Bart., B.A. .	Broom Hill, Tunbridge Wells.
Sanger, Thomas Henry . .	Postal Telegraphs, Dublin.
Saunders, H. C. . . .	Eastern Telegraph Company, 66, Old Broad Street, E.C.
Saunders, J. B. . . .	Teignmouth.
Schramm, Otto	12, Queen Anne's Gate, Westminster, S.W.
Scratchley, P. H., Lieut.-Col., R.E. .	Public Works Office, Melbourne, Victoria, Australia.
Sharpe, Charles J. . . .	27, Gt. George Street, Westminster, S.W.
Sheath, Alfred . . .	"Villette," New Street, North Brighton, Victoria, Australia.
Shoolbred, James N., B.A., M. Inst. C.E.	3, Westminster Chambers, Victoria Street, S.W.
† Siemens, Carl, M.Inst.C.E. . .	Messrs. Siemens & Halske, St. Petersburg
SIEMENS, CHARLES WILLIAM, D.C.L., LL.D., F.R.S. (*Past President.*)	12, Queen Anne's Gate, Westminster, S.W.
SIEMENS, ALEXANDER . . (*Member of Council.*)	12, Queen Anne's Gate, Westminster, S.W.
Simkins, A. R. M. . . .	
Simmons, Sir J. Lintorn, Gen., R.E., G.C.B.	36, Cornwall Gardens, S.W.

* SIVEWRIGHT, JAS., M.A., C.M.G. (*Honorary Secretary for the Cape and South Africa.*)	General Manager of Telegraphs, Cape of Good Hope.
SKINNER, T.	Postmaster-General and Director of Telegraphs, Colombo, Ceylon.
SKINNER, M. W., Lieut., R.E. .	Ordnance Survey Office, 43, Parliament Street, S.W.
SLEEMAN, C. W.	18, Adam Street, Adelphi, W.C.
SMITH, BENJAMIN . . .	Eastern Telegraph Company, Aden.
SMITH, R. M., Lt.-Colonel, R.E. .	Director of the Indo-European Government Telegraphs, Teheran, Persia.
SMITH, THEOPHILUS . . .	Alcester, Redditch.
SMITH, WILLOUGHBY (*Vice President.*) . .	18, Wharf Road, City Road, N.
SNELL, H.	Estrada de Ferro de Natal, Natal, Rio Grande do Norte, Brazil.
SPAGNOLETTI, C.E. (*Vice-President.*) . .	G. W. Railway, Paddington, W.
SPRAGUE, J. T.	315, Green Lane, Birmingham.
STACEY, CHARLES H. . . .	Eastern Telegraph Company, Aden.
STERNE, LOUIS	9, Victoria Chambers, Westminster, S.W.
STIFFE, ARTHUR W. . . .	Manora, Hollington Park, St. Leonard's-on-Sea.
ST. JOHN, O. B. C., Lieut.-Col., R.E., C.S.I.	Political Officer, Kandahar, India.
STOCKLEY, Lieut.-Col., R.E. . .	Portsmouth.
STONE, Dr. W. H., M.A., F.R.C.P. .	14, Dean's Yard, Westminster, S.W.
STOTHERD, R. H., Col., R.E. . .	Mountjoy Barracks, Phœnix Park, Dublin.
STROH, AUGUSTUS (*Member of Council.*) . .	98, Haverstock Hill, N.W.
SWAN, JOSEPH W. . . .	Mosley Street, Newcastle-on-Tyne.
SYMONS, KYRLE EMILE . . .	Indian Government Telegraphs.
TALBOT, FRANK F. . . .	Telegraph Superintendent, Central Argentine Railway, Rosario de Sta. Fé.
TANSLEY, EDWARD . . .	Postal Telegraphs, Glasgow.
TAYLOR, HERBERT, C.E. . .	7, Pope's Head Alley, Cornhill.
TEALE, FRED. G. (*Acting Honorary Secretary for India.*) . .	Indian Government Telegraphs, Calcutta.
TERNANT, A. L. . . .	2, Boulevard du Muy, Marseilles.
TERP, JULIUS	Great Northern Telegraph Company, Aberdeen, N.B.
THOMPSON, H. E. . . .	Indian Government Telegraphs, Alipore.
THOMPSON, PROFESSOR SILVANUS P., B.A., D.Sc., F.R.A.S.	University College, Bristol.

THOMSON, SIR WILLIAM, F.R.S. LL.D. (*Past President.*)	The University, Glasgow, N.B.
THORNTON, M. L. E. . . .	Indian Government Telegraphs, Calcutta.
TICEHURST, F. G. . . .	The Old House, Battle, Sussex.
TIDDY, WILLIAM N. . . .	12, Princes Street, Hanover Square, W.
TIETGEN, C. F.	Privatbanken, Copenhagen.
TODD, CHARLES, C. M. G. (*Honorary Secretary for South Australia.*) .	Director-General, South Australian Telegraphs, Adelaide, Australia.
TOWERS, G. L.	Indian Government Telegraphs.
TREUENFELD, R. VON FISCHER .	12, Queen Anne's Gate, Westminster, S.W.
TROWER, M. R.	(Indian Government Telegraphs) care of Messrs. Grindlay, Groom, & Co., Bombay.
* TRUMAN, EDWIN THOMAS . .	23, Old Burlington Street, W.
TUBB, H. H.	5, Charlton Terrace, Friern Road, Lordship Lane, East Dulwich.
TURNER, H. F., Major R.E. . .	Postal Telegraphs, Bristol.
TYNDALL, Professor JOHN, LL.D., F.R.S.	Royal Institution, Albemarle Street, W.
VARLEY, C. F., F.R.S., M. Inst. C.E. (*Member of Council.*)	1, Great Winchester Street Buildings, Old Broad Street, E.C.
VARLEY, F. H.	Mildmay Park Works, Stoke Newington, N.
WALKER, C. V., F.R.S., F.R.A.S., F.M.S. (*Past President.*)	Fern Side, Reigate Hill, Surrey.
WALKER, E. O. . . .	Indian Government Telegraphs.
WALKER, SIDNEY F. . . .	Black Boy Yard, Long Row, Nottingham
WALSH, JOHN	2, Blanche Villas, Stretford, near Manchester.
WARBURTON, E. C. . . .	Telegraph Department, Lancashire and Yorkshire Railway, Manchester.
WARD, A. R.	Indian Government Telegraphs.
WARD, G. G. . . . . (*Honorary Secretary for N. America.*)	Direct United States Cable Company, 16, Broad Street, New York.
WARDEN, W. M. . . .	Broad Street, Birmingham.
* WEAVER, HENRY . . .	Caton Lodge, Streatham Hill, Surrey.
WEBB, E. MARCH . . .	India Rubber Company, Silvertown, E.
WEBB, F. C., M. Inst. C.E. . .	Palace Chambers, Bridge Street, Westminster, S.W.
WEBBER, C. EDMOND, Lt.-Col., R.E. (*President.*)	Alvercliff, Gosport, Hants.
WELLS, T. H.	The Anglo-American Telegraph Company, 26, Old Broad Street, E.C.

* WHITEHOUSE, E. O. WILDMAN	Down Place, Harting, Petersfield.
WIESE, W.	Indian Government Telegraphs, Calcutta.
WILLIAMS, W.	Indian Government Telegraphs, Calcutta.
WILSON, WILLIAM I., F.C.S.	2, Westwick Gardens, Shepherd's Bush, W.
WINTER, G. K., F.R.A.S.	Arconum, near Madras.
WINTER, WILLIAM HENRY	Postal Telegraphs, General Post Office.
WOLLASTON, CHARLTON	9, Great Winchester Street, E.C.

Total Number of Members . . . . 366.

ASSOCIATES.

* Adams, Alex. J. S.	Postal Telegraphs, General Post Office.
Adamson, E. W.	Submarine Telegraph Company, Eastdean, Eastbourne.
Addison, G. W., Capt., R.E.	War Office, Whitehall, S.W.
Aird, John	Belvedere Road, Lambeth.
Aldis, Robert W.	Postal Telegraphs, Colchester.
Allen, C. E.	Indo-European Government Telegraphs, Bushire.
Allen, J. J.	Indian Government Telegraphs, Calcutta.
Allen, Percy	Woodbury Hill, Loughton, Essex.
Almack, Edward	King's College Hospital.
Almond, George B.	Eastern Telegraph Company, Candia, Crête.
Anders, George L.	31, Queen Victoria Street, E.C.
Anderson, James	Eastern Telegraph Company, Syra.
Anderson, Thomas	176, Abbott Road, Poplar, E.
Andrew, John R.	Telegraph Department, London and North Western Railway Company, Chester.
Andrews, J. D. F.	National Electric Company, 48, West George Street, Glasgow.
Andrews, S.	Postal Telegraphs, G.P.O., E.C.
Anstruther, Ralph W., Lieut., R.E.	Care of Messrs. Cox & Co., Agents, London.
Ascough, T. B.	Postal Telegraphs, Telegraph Street, E.C.
Ash, William H.	Eastern Telegraph Company, Porthcurno, Penzance.
Ashton, Edwin	Postal Telegraphs, Cambridge.
Bagnold, Arthur H., Lieut., R.E.	Junior United Service Club, St. James', S.W.
Bailey, J. F.	
Bailey, S. S.	Anglo-American Cable Company, Heart's Content, Newfoundland.
Baines, A. E.	Eastern Telegraph Company, Aden.
Ballard, W. H.	Postal Telegraphs, Plymouth.
Bambridge, G. H.	Compagnie Française du Télégraphe, de Paris à New York, 100, Gresham House, E.C.
Banker, S. M.	Avon Villa, Pellatt Grove, Wood Green, N.
Barker, Edward R.	Brazilian Telegraph Company, Caixa Correio, 120, Pernambuco, Brazil.
Barrett, Professor W. F.	Science and Art Department, Dublin.
Barry, P. F.	6, Alfred Street, Cork.

Baskett, G. W.	Albert Lodge, Colchester.
Baxter, William J.	29, Almorah Road, Islington, N.
Bayly, Brackenbury	Government Telegraphs, Cape Town.
Bayly, Robert	Torr Grove, Plymouth.
Bazeley, Thomas	Postal Telegraphs, Cardiff.
Beaumont, Commander L. A., R.N.	H.M.S. "Excellent," Portsmouth.
Beckett, J. W.	Postal Telegraphs, Lancaster.
Beckingsale, Edgar William	Bedford Park, Turnham Green, W.
Belfield, Reginald	Llyndally, 1, Palace Road, Streatham Hill, S.W.
Bell, Alexander Carlyle	Thames Chambers, 12, York Buildings, Adelphi, W.C.
Belville, William	Ferro Carril del Sud, Buenos Ayres.
Ben'est, Henry	15, Campbell Road, Bow, E.
Bennett, F. W., Lieut., R.E.	British Post Office, Constantinople.
Bent, William	22, Calvert Road, East Greenwich, S.E.
Beresford, James	Messrs. Richard Johnson & Nephew, Manchester.
Berly, J. A.	Compagnie Générale d'Electricité, 16 New Bridge Street, E.C.
Berrington, Evelyn D. D.	Eastern Telegraph Company, 2, Boulevard du Muy, Marseilles.
Berner, I. O. L.	Great Northern Telegraph Company, 119, Bishopsgate Street Within, E.C.
Bewick, T. J., C.E.	Haydon Bridge, Northumberland.
Bidwell, Shelford, M.A., LL.B.	Riverstone Lodge, Wandsworth.
Black, Francis Daniel	Aske Villa, Heaton Moor, near Stockport.
Blackmore, C., Sergeant, R.E.	Indo-European Government Telegraphs, Persia.
Blakey, Edwin	Northern Telegraph Works, Halifax.
Blandford, William	Telegraph Department, Ballarat, Victoria, Australia.
Blewett, George	17, Osborne Road, Tollington Park, N.
BLUNDELL, J. WAGSTAFFE (*Auditor.*)	12, Delahay Street, Westminster.
Bolton, F.	Eastern Telegraph Company, Salonica, Turkey.
Bolton, Walter	22, Athelstone Road, St. Stephen's Road, near Bow, E.
Bompas, G. C.	4, Great Winchester Street Buildings, E.C.
Bosse, Karel, P.J.S.	India Rubber Company, Silvertown.
Bosomworth Wm.	8, Broomfield Terrace, Chapel Lane, Headingley, Leeds.
Botham, Arthur, Serjeant, R.E.	Postal Telegraphs, Portsmouth.
Bottomley, J. T.	The College, Glasgow, N.B.

BOTTOMLEY, WILLIAM . . .	2, Eton Terrace, Hillhead, Glasgow.
BOTTOMLEY, W. F. . . .	Messrs. David Moseley & Sons, 2 & 4, New Brown Street, Manchester.
BOURNE, ROBERT O. . . .	General Inspector, Post and Telegraph Department, Bowen, Queensland, Australia.
BRADLEY, RICHARD . . .	82, Victoria Terrace, Ashton-under-Lyne
BRADSHAW, Sergt. A. D., R.E. .	Brompton Barracks, Chatham.
BRAIN, W. B.	St. Annals, Cinderford, Gloucester.
BRAYSHAW, T. H. . . .	Eastern Telegraph Company, Cyprus.
BROCKIE, J.	British Electric Light Company, Heddon Street, Regent Street, W.
* BRODIE, COLIN	Private Wire Department, Secretary's Office, G.P.O.
BROOK, ALBERT	Direct United States Cable Company, 53, Old Broad Street, E.C.
BROOK, WALTER	Direct United States Cable Company, 53, Old Broad Street, E.C.
BROWN, FREDERICK . . .	44, Upper George Street, W.
BROWN, JAMES	Direct United States Cable Company, 16, Broad Street, New York, U.S.
BROWN, R. T.	6, Cicely Road, Hanover Park, Peckham, S.E.
BROWNE, HENRY V. . . .	Direct Spanish Telegraph Company, Barcelona.
BROWNING, WILLIAM W. . .	Eastern Extension Telegraph Company, Singapore.
BUCKNILL, J. T., CAPT., R.E. (*Associate Member of Council.*) .	Thorn Hill, Bitterne, Hants.
* BULLIVANT, W. M. . . .	2, London Street, E.C.
BULLOCK, THOMAS A. . . .	Eastern Telegraph Company, 66, Old Broad Street, E.C.
BUTCHER, S.	Indo-European Telegraph Department, Kurrachee.
BUTLER, ARTHUR . . .	Eastern Extension Telegraph Company, Singapore.
BYRNE, T. H.	Brighouse, Yorkshire.
CAILLARD, V., Lieut. R E. . .	Gosport.
CAMPBELL, EDWARD . . .	Postal Telegraphs, Glasgow.
CAREW, W. R. H.	
CARLISLE, HENRY . . .	Eastern Telegraph Company, Port Durban, Natal.
CARPENTER, F. H. . . .	Western and Brazilian Telegraph Company, Maranham.
CARR, GEORGE, Lieut., R.E. . .	H.M.S. "Hood," Chatham.
CARR, GEORGE M. . . .	Postal Telegraphs, Sunderland.

CARSON, J. H.	Anglo-American Telegraph Company, 26, Old Broad Street, E.C.
CASSERLEY, S. W., LL.B. . .	7, Crown Office Row, Temple, E.C.
CHALLEN, PETER R. . . .	Victorian Posts and Telegraph Department, Melbourne, Victoria, Australia
CHAMBERS, JOHN CHARLES . .	Postal Telegraphs, Leeds.
CHEESMAN, H. G. . . .	Eastern Telegraph Company, Lisbon.
CHERRILL, NELSON K. . . .	Bedford Lodge, Shortlands, Kent.
CHETWYND, EUSTACE W. . .	Receiver and Accountant-General's Office, G.P.O., E.C.
CHEVALLIER, C.	Eastern Telegraph Company, Aden.
CHEVALLIER, FIELDING . . .	India Rubber Company, Silvertown, E.
CLAPPERTON, GEORGE . . .	Direct United States Cable Company, 16, Broad Street, New York, U.S.
CLARKE, W., Sergeant, R.E. . .	Indo-European Government Telegraphs, Shiraz, Persia.
CLEMENT, ADAM F. . . .	North British Railway, Edinburgh.
CLEMENTS, G. M. . . .	17, Gresham House, E.C.
CLIPPERTON, HENRY . . .	Eastern Extension Telegraph Company, Singapore.
COCHRANE, W. H. . . .	St. Stephen's Chambers, Telegraph Street, E.C.
COCKBURN, A. C., F.C.S. . .	64 Longridge Road, Kensington, W.
COFFIN, WALTER H., F.C.S., M.Phys.S.	94, Cornwall Gardens, South Kensington, S.W.
COLE, C. J.	Eastern Extension Telegraph Company, Rangoon.
COLEMAN, ALFRED . . .	National Telephone Company, Room 204, Swan Arcade, Bradford.
COLLEY, BENJAMIN W. . . .	Anglo-American Telegraph Company, St. Pierre, Newfoundland.
COLLINGS, CHARLES E. . . .	Postal Telegraphs, Plymouth.
COLLINS, EBENEZER . . .	Cape Government Telegraphs, Murraysburg, Cape Colony.
COOPER, M.	Postal Telegraphs, G.P.O., E.C.
CORNER, CHARLES R. . . .	3, Copthall Chambers, Throgmorton Street, E.C.
COX, F. W. POPE . . .	Bedford Chambers, Plymouth.
CRABTREE, GEORGE . . .	Eastern Telegraph Company, Malta.
CRAMPTON, T. RUSSELL, M. Inst. C.E. (*Associate Member of Council.*)	4, Victoria Street, S.W.
CRILLY, JOHN HAMILTON . .	Anglo-American Telegraph Company, Brest.
CROAL, T. A.	Postal Telegraphs, Edinburgh.
CROFTON, EDWARD . . .	2, Dr. Johnson's Buildings, Inner Temple, E.C.

CUFF, JOHN C.	Eastern Extension Telegraph Company, Singapore.
CUNNINGTON, JOSEPH G. S.	17, Gilbert Terrace, Trierson Road, West Hampstead.
DALLAS, JOHN	21, Alma Square, St. John's Wood.
DALLAS, THOMAS E.	West Coast of America Telegraph Company, 98, Cannon Street, E.C.
DALTON, SAMUEL T.	41, Torriano Avenue, Camden Rd., N.W.
DALY, HENRY DE BURGH	Metropolitan Surveyor's Office, G.P.O., 4, Adelaide Street, Charing Cross, W.C.
DANVERS, F. C. (*Auditor.*)	India Office, S.W.
DAVIES, DAVID	7, Gower Street, W.C.
DAVIES, F.	
DAVIES, J. R.	Indian Government Telegraph Department.
DAVIES, WILLIAM HENRY	Exchange Telegraph Company, 17, Cornhill, E.C.
DAVIS, JAMES	51, Tyrrell Street, Bradford, Yorkshire.
DAVIS, JOSEPH	"Fitzroy Works," 6, Kennington Park Road, S.E.
DEARLOVE, ARTHUR L.	Care of Messrs. Clark, Forde, & Co., 7, Pope's Head Alley, Cornhill, E.C.
DEW-SMITH, A. G., M.A.	Trinity College, Cambridge.
DICKENSON, SAMUEL S.	Direct United States Cable Company, Torbay, Nova Scotia.
DICKENSON, W.	Anglo-American Telegraph Company, Heart's Content, Newfoundland.
DIESELHORST, WILHELM	Messrs. Siemens Brothers & Co., Charlton, S.E.
DOHERTY, JOHN	Postal Telegraphs, Manchester.
DONALD, JOHN	Postal Telegraphs, Stranraer.
DONALDSON, J.	Postal Telegraphs, Reading.
DOUGLAS, SHOLTO MCKENZIE	Tjinta Radja, Langkat, Penang, Sumatra.
DOWSON, HAROLD	Sandhurst Lodge, East Worthing.
DOWSON, J. EMERSON	3, Great Queen Street, Westminster, S.W.
DRAPER, GEORGE	Secretary Eastern Telegraph Company, 66, Old Broad Street, E.C.
DRAPER, JOHN H.	Finkle Street, Stockton-on-Tees.
DRIVER, GEORGE	British Telegraph Works, 406, Euston Road, N.W.
DRUITT, E., Lieut., R.E.	Pembroke Dock.
DUBERLY, F.	Eastern Extension Telegraph Company, Penang, Straits Settlement.
DUBERN, GEORGE	Calcutta.

Ducloy, Jacques F.	Submarine Telegraph Company, Threadneedle Street, E.C.
Duff, B.	Government Telegraph Department, Cape of Good Hope.
Dunbar, William	Inspector of Telegraphs, Cape Colony.
Dunn, Andrew S.	Telegraph Department, Caledonian Railway Company, Glasgow, N.B.
Durran, William	Eastern Telegraph Company, Bombay.
Dyer, F. W.	Postal Telegraph Stores, Bolton, Lancashire.
Earle, Edward	Anglo-American Telegraph Company, St. Pierre, Newfoundland.
Earle, Samuel A.	Anglo-American Telegraph Company, St. Pierre, Newfoundland.
Ebel, Julius	Compagnie Française du Télégraphe de Paris à New York, 100, Gresham House, E.C.
Eden, Augustus	Postal Telegraphs, Edinburgh.
Edgar, James	Post Office, Wrexham.
Edwards, J. P.	Government Telegraphs, Cape Town.
Elam, Dr.	75, Harley Street, W.
Elliott, Thomas	Engineer's Department, Postal Telegraphs, Hull.
Emmott, Walter	Northern Telegraph Works, Halifax, Yorkshire.
Erichsen, Herman	Grove Cottage, Upper Tooting, S.W.
Evans, Frederick E.	Postal Telegraphs, Birmingham.
Eymers, F. C.	Nile Cottage, Wood St., Woolwich, S.E.
Falck, D. Anosi	Government Telegraphs, Grahamstown, Cape Colony.
Falck, A.	Great Northern Telegraph Company, Gothenberg, Sweden.
Fargues, John	Telegraph Department, Teheran, Persia.
Ferguson, Henry	Intelligence Section, Secretary's Office, G.P.O., E.C.
Feytens, P. F.	Direct Spanish Telegraph Company, Marseilles.
Field, Charles Leopold	Upper Marsh, Lambeth.
Feilding, Maj.-Gen. the Hon. W.	23, Brook Street, W.
* Fleetwood, Charles Thos.	Post Office Telegraphs, General Post Office, E.C.
Fletcher, Thomas	36, Coleman Street, E.C.
Ford, T.	Postal Telegraphs, Bolton.
Forshaw, Alfred C.	Direct United States Cable Company, 34, Throgmorton Street, E.C.

Fothergill, J. W.	Anglo-American Telegraph Company, St. Pierre, Newfoundland.
Franklin, James	Bombay and Baroda Railway Company, Bombay.
Fraser, Arthur J.	14, Buckingham Street, Charing Cross, W.C.
Fraser, John	Direct United States Cable Company, Rye Beach, U.S.
Fraser, Percy S.	Inspector of Telegraphs, Cape of Good Hope.
Fraser, W. J.	Direct United States Cable Company, Rye Beach, U.S.
French, J.	Indian Government Telegraphs, Bellary, India.
French, S. R.	Secretary's Department, Postal Telegraphs, General Post Office, E.C.
FROST, ALFRED, J. (*Librarian.*)	6, Westminster Chambers, Victoria Street, S.W.
Fry, J. O.	
Fulford, R. B., Lieut., R.N.	H.M.S. "St. Vincent," Gosport.
Fuller, George	Newcastle Wharf Works, Old Ford Road, Bow, E.
Fulton, C.	Anglo-American Telegraph Company, 26, Old Broad Street, E.C.
Gallwey, Edward, Lieut., R.N.	H.M.S. "Vernon," Portsmouth.
Gaines, M. J.	Anglo-American Telegraph Company, Duxbury, Mass., U.S.
Gatehouse, T.	7, Foreign Street, Loughboro' Junction, S.E.
Gee, Basil	Enderby's Wharf, Greenwich, S.E.
George, Frederick	Deputy Inspector-General of Egyptian Telegraphs, Cairo.
Gibbs, Douglas	Eastern Telegraph Company, Alexandria, Egypt.
Gibson, James	Postal Telegraphs, Edinburgh.
Gifford, F. W.	Indo-European Government Telegraphs, Shiraz, Persia.
Gilbert, John J.	72, Cambridge Street, The Crescent, Birmingham.
Gilhespy, Wm.	Eastern Telegraph Company, Cairo.
Gisborne, Francis H.	Telegraph and Signal Service, Ottawa, Canada.
Gladstone, Charles E., Lieut., R.N.	H.M.S. "Vernon," Portsmouth.
Glegg, Alexander	Care of Messrs. Bowen & Co., Phœnix Foundry, Mount Pleasant, Clerkenwell.

Gooch, William D.	25, Haworth Buildings, 5, Cross Street, Manchester.
Goodman, H. M.	"Avalon," Catford Hill, Catford, Kent.
Goodsall, Captain W.	17, Bartlett's Buildings, Holborn Circus, E.C.
Goodwin, M.	1, Bank of England Place, Plymouth.
Gordon, George Keith, Lieut. R.N.	
Grace, C. H.	Eastern Extension Telegraph Company, Rangoon.
Graham, Alfred	9, Graces Road, Camberwell.
Graham, W. J.	1, White House Villas, Woodland Terrace, Charlton, S.E.
Granville, William P.	195, Southgate Road, N.
Graves, A.	5, Clarence Place, Clapton Square, Lower Clapton, E.
Graves, E.	Indo-European Government Telegraphs, Teheran, Persia.
Gray, H.	Indo-European Telegraph Company, Teheran, Persia.
Greenhill, J. E.	Downs Park Road, Clapton, E.
* Greer, MacGregor, Captain, R.E.	Westminster Palace Hotel, S.W.
Grindle, George A.	Linden House, Cambridge Gardens, Notting Hill, W.
Gripper, Francis E.	19, Great George Street, Westminster, S.W.
Groves, William	89, Bolsover Street, Portland Place.
Gümpel, C. Godfrey	49, Leicester Square, W.C.
Gurdon, W. B., C.B.	The Treasury, S.W.
Hackshaw, T.	Indo-European Telegraph Company, Teheran, Persia.
Hager, C. W.	Messrs. Siemens Bros. & Co., Woolwich, S.E.
Hall, Walter	6, Pier Road, Erith.
Hamilton, Major, R.E.	Aldershot.
Hamilton, F. A.	Anglo-American Telegraph Company, 26, Old Broad Street, E.C.
Hamilton, W. Tighe	The Orchards, Palmerston Park, Dublin.
Harben, Alfred	3, Melita Villas, Victoria Road, Charlton, S.E.
Harborow, Henry	4, Circus Street, Marylebone, W.
Hardwick, W.	Indo-European Government Telegraphs, Persia.
Harrison, Hugh E., B.Sc.	Messrs. Hammond & Co., Wharncliffe Chambers, Sheffield.
Harrison, R. H.	Highfields, Ware, Herts.

Harrison, Thos.	Postal Telegraphs, Newcastle-on-Tyne.
Hasdell, H. D.	Post Office Savings Bank, Queen Victoria Street, E.C.
Haskayne, Henry	67, Christopher Street, Burley Road, Leeds.
Hassard, H. S., Captain	2nd Battalion Berks Regiment, New Barracks, Gosport, Hants.
Hawker, E. C. T., Lieut., R.E.	H.M.S. "Hood," Chatham.
Heath, E. F.	The Beeches, Norwich.
* Heaviside, O.	3, St. Augustine's Road, N.W.
Herbert, Ernest G.	18, Calverley Park, Tunbridge Wells.
Henley, George	47, Drayton Park, Highbury, N.
Henry, Robert	Government Telegraph Department, Hobart, Tasmania.
Heraghty, G. J.	Eastern and South African Telegraph Company, Lourenço Marques, Delagoa Bay.
Herne, Robert	Direct United States Cable Company, Rye Beach, New Hampshire, U.S.
Hesse, Frederick E.	Secretary, Eastern Extension Telegraph Company, 66, Old Broad Street, E.C.
Hewett, John S.	The Indian Government Telegraph Department.
* Hill, Joseph Tripp	Postal Telegraphs, G.P.O., E.C.
Hill, Thomas	Postal Telegraphs, Telegraph Street, E.C.
Hilliard, Augustus	Marine Hotel, Tidal Basin, Victoria Dock.
Hiscott, A. B.	Telégrafos (La ciudad), Mexico.
Hitchcock, H. L.	Eastern Telegraph Company, Quinta Nova, Carcavellos, Lisbon.
Hockey, Sergt. S., R.E.	Indo-European Government Telegraphs, Konar Takhteh, Persia.
Hockley, T. T.	(Indo-European Telegraph Department, Kurrachee) Westfield Pl., Surbiton.
Hogge, R.	Western and Brazilian Telegraph Company, Caixa 76, Rio Grande do Sul, Brazil.
Holmes, George	Eastern Telegraph Company, Malta.
Holt, John S.	United Telephone Company, 36, Coleman Street, E.C.
Hookey, James	Postal Telegraphs, General Post Office, E.C.
Hooper, Rev. Samuel F., B.A.	17, Lorrimer Square, Walworth, S.E.
Huggins, James	Ferro Carril del Sud, Buenos Ayres.
Humble, George	Postal Telegraphs, Newcastle-on-Tyne.
Imray, Harold	Sedgemere, East End, Finchley, N.

IRMINGER, FREDERICK . . .	Great Northern Telegraph Company, Hong Kong, China.
ISMAY, J.	Haddon Villa, 26, Trafalgar Road, Egremont, Birkenhead.
JACKSON, R. RAYNSFORD, Colonel .	Ashurst, West Hill, Sydenham, S.E.
JAMES, C. S.	Indian Government Telegraph Department.
JEBB, J. GLADWYN . . .	
JEFFERY, JAMES	The Direct Spanish Telegraph Company, 25, Church Street, Falmouth, Cornwall.
JOBSON, HOWARD C. . . .	Dudley.
JOEL, H. F.	44, Lavender Grove, Dalston, E.
JOHNSTONE, THOMAS Y. . .	Persian Gulf Telegraphs, Fao Station.
JONES, JAMES HAIG D. . . .	Eastern Extension Telegraph Company, Penang.
JONES, JOHN RYMER . . .	22, Castletown Road, West Kensington, W.
JONES, REGINALD J. . . .	34, Victoria Road, Middlesborough.
JONES, W. O.	17, Bolton Gardens, South Kensington, S.W.
KENNEY, F., Sergeant-Major, R.E. .	Postal Telegraphs, Walpole Street, New Cross, S.E.
KIDD, J. C.	Indian Government Telegraphs, Calcutta.
KIERZKOWSKI-STEUART, CHARLES F. DE, M. Inst. C.E. . . .	7, Collingham Road, Cromwell Road, S.W.
KING, JOSEPH T. . . .	Compania Telegrafico del Rio de la Plata, Buenos Ayres.
KING, W. F., F.R.S.E. . .	Lonend, Trinity, Edinburgh.
KINGSFORD, H.	26, Old Broad Street, E.C.
KINGSLAND, WM. . . .	32, Harold Street, Holland Road, Brixton, S.W.
KIRBY, GEORGE J. . . .	Cape Telegraphs, Port Elizabeth.
KNIGHT, H. P., Lieut. R.E. . .	Shaftesbury Villa, Brockhurst, Gosport.
KRAUSE, RUDOLPH H. . . .	Edison Gower-Bell Telephone Company, 6, Lombard Street, E.C.
LACHLAN, WILLIAM . . .	446, Strand, W.C.
LALONDE, E. L.	30, Lorne Terrace, Annandale Road, Greenwich, S.E.
LAMB, J. C.	Postal Telegraphs, General Post Office, E.C.
LANGMAN, ALFRED . . .	Postal Telegraphs, Cambridge.

LAPHAM, T. W., Sergt., R.E.	8, St. Leonard's Terrace, Mount Radford, Exeter.
LAURIE, E. H.	16, Blandford Square, N.W.
LAWSON, ED. G.	Superintendent, Brazilian Submarine Telegraph Company, St. Vincent, Cape de Verde.
LECOAT, E. J.	The Eastern Telegraph Company, Bona, Algiers.
LEONARD, W.	South Eastern Railway Telegraphs, London Bridge.
LEPELLEY, C. A.	Submarine Telegraph Company, Threadneedle Street, E.C.
LESSELS, DAVID	Care of Mr. J. Cowans, Inspector, Post Office Telegraphs, Glasgow.
LIVINGSTON, JAMES	467, New City Road, Glasgow.
LOAM, JOHN	The Indo-European Telegraph Department, Jask, Persian Gulf.
LOGAN, JAMES K.	Inspector of Telegraphs, Dunedin, New Zealand.
LONDON, ROBERT	84, Tyrwhitt Road, Lewisham High Road, New Cross, S.E.
LOPEZ, EUSTACE J.	Indian Government Telegraphs, Calcutta.
LOVEY, A. FÉRI	20, The Common, Woolwich, S.E.
LOWE, M. H.	2, Falcon Court, Fleet Street, E.C.
LOWE, THOMAS	8, Great Winchester Street Buildings, E.C.
LUCAS, F. R.	Park Lodge, Hervey Road, Kidbrook, S.E.
LYNE, C.	Indo-European Government Telegraphs, Persia.
LYSTER, W. G.	Post Office, Reading.
MACCLURE, J. H.	Beaconsfield Club, Marlborough Gate. Pall Mall, S.W.
MACDONNELL, A. C., Lieut., R.E.	Care of Messrs. Cox & Co., Agents, London.
MACKENZIE, J. KENNETH D.	Elswick Ordnance Works, Newcastle-on-Tyne.
MACWHIRTER, W.	Messrs. Norman & Son, Barrow-in-Furness.
MADGEN, WILLIAM L.	National Telephone Company, 3, High Street, Belfast.
MARKHAM, THOMAS THORNHILL	102, Fetter Lane, E.C.
MARSH, H.	3, Windsor Terrace, Buckland, Dover.
MASON, WILLIAM B.	Telegraph Department, Nagasaki, Japan.

Massey, W. H.	Electric Light and Power Generator Company, 47, Cannon Street, E.C.
Mathews, Henry M. S.	Indian Government Telegraphs.
Matthias, R.	Indo-European Telegraph Company, Persia.
May, Joseph	Telegraph Construction and Maintenance Company, Enderby's Wharf, East Greenwich.
McGauran, D. J.	Manager Telegraph, Office, Albury, New South Wales.
McKinney, Alexander	Postal Telegraphs, Manchester.
McLean, James	2, Ovington Square, S.W.
Mehrtens, John	Percy Cottage, Pellatt Grove, Wood Green, N.
Michael, Wm. H., Q.C.	4, King's Bench Walk, Temple, E.C.
Middleton, J. E.	Inspector of Telegraphs, Transkie, South Africa.
Miller, Leslie B.	34, Darnley Road, Hackney, E.
Moffatt, Alexander C.	26, College Street, Dowgate Hill, E.C.
Moll, Oscar	Direct United States Cable Company, 53, Old Broad Street, London.
Moon, William	67, Moray Road, Tollington Park, N.
Moore, C. W.	3, High Street, Belfast.
Morgan, Charles Amiss	Postal Telegraphs, General Post Office.
Morgan, F.	Postal Telegraphs, General Post Office, E.C.
Morrison, G. J., C.E.	Care of Messrs. Jardine, Matheson, & Co., Shanghai.
Morrison, G., Serjeant-Major, R.E.	Postal Telegraphs, Victoria Street, Bristol.
Moseley, Charles	Chapel Field Works, Ardwick, Manchester.
Mudford, F. J.	77, Mildmay Grove, N.
Mummery, J. Howard, M.R.C.S.	10, Cavendish Place, W.
Munro, John	4, Montague Road, West Croydon.
Murphy, Charles J.	3, Circus, Tower Hill.
Musgrove, H. M.	Messrs. Norman & Son, Barrow-in-Furness.
Mygind, John	Great Northern Telegraph Company, Newcastle-on-Tyne.
Naylor, J. E.	Postal Telegraphs, Leeds.
Needham, R. J.	Anglo-American Telegraph Company, Duxbury, Mass., U.S.
Nevett, F. W.	
Newbury, George C.	Postal Telegraphs, General Post Office, E.C.

NEWMAN, A. E.	Compañia Telegrafica del Rio de la Plata, Monte Video.
NEWNHAM, W. A.	Indo-European Government Telegraphs Jask, Persian Gulf.
NICHOLSON, JAMES	Compañia Telegrafica del Rio de la Plata, Monte Video.
NUNN, THOMAS WILLIAM	8, Stratford Place, W.
OAKSHOTT, A.	Postal Telegraphs, Southampton.
OATWAY, ARTHUR	Postal Telegraphs, General Post Office, E.C.
O'DONNELL, C. E.	The Indian Government Telegraph Department.
OGG, F. WILLIAM	11, Barclay Terrace, Leytonstone, Essex.
O'HAIRE, J. M.	Government Telegraphs, Cape of Good Hope.
ORCHISTON, J.	Telegraph Department, Auckland, New Zealand.
OWEN, FRITZ CUNLIFFE	Anglo-American Brush Electric Light Corporation, 74, Hatton Garden, E.C.
PAGE, ALFRED S.	India Rubber Company, Silvertown.
PAGE, CHARLES J.	Care of Mr. C. Page, 2, St. Ann's Terrace, Love Lane, Wandsworth.
PARMITER, ALBERT	Postal Telegraphs, Gloucester.
PARSONS, The Hon. RICHARD	Airedale Foundry, Leeds.
PAUL, A. J. E.	Eastern Telegraph Company, Bona, Algiers.
PAUL, A. L.	16, Kensington Square, W.
PATEY, CHARLES H. B. (*Associate Member of Council.*)	The Cedars, Bickley.
PATTEN, FREDERICK A.	Care of Messrs. Grindlay & Co., 55, Parliament Street, S.W.
PAYN, JOHN J.	Eastern Telegraph Company, Marseilles.
PAYTON, WILLIAM	66, Old Broad Street, E.C.
PERKINS, E. J.	
PENROSE, COOPER, Lieut., R.E.	Bermuda.
PERRY, F.	Anglo-American Telegraph Company, Heart's Content, Newfoundland.
PETERS, ALFRED	Western and Brazilian Telegraph Company, Bahia.
PETERSEN, K.	German Union Telegraph Company, 4, Werder Strasse, Berlin.
PETTERSON, OSCAR F.	
PHILIPPS, W. REES	Care of H. Rees Philipps, Esq., M.A., India Office, S.W.
PHILLIPS, C. H.	16, Greenwood Terrace, St. John's Church Road, Hackney, E.

Picken, William	2, Mardale Parade, Gateshead.
Pierce, Edwin	Persian Gulf Telegraphs, Gwadur, Persian Gulf.
Portelli, Robert	Eastern Telegraph Company, Malta.
Porter, Charles	93, Balfour Road, Highbury New Park, N.
Price, H. N. Blackwood	Trieste-Corfu Telegraph, Via Carintia 12, Trieste.
Probert, J.	Postal Telegraphs, Moorgate Street Buildings, E.C.
Puget, Colonel Granville W.	34th Regiment, Ferozepore, India.
Pyne, Stree Bollychand	Indian Government Telegraphs, Calcutta.
Quick, James	Royal Arsenal Science Schools, Woolwich, S.E.
Rathborne, H. H.	Porthcurnow, near Penzance, Cornwall.
Raymond, George	Eastern Telegraph Company, Tenedos, Turkey.
Reynell, C. H.	Brazilian Submarine Telegraph Company, Madeira.
Rich, H. R.	Indian Government Telegraphs, Calcutta.
Richards, A., Sergeant R.E.	Canterbury.
Richardson, Captain A. H.	Eastern Telegraph Company, 66, Old Broad Street, E.C.
Richardson, H.	Postal Telegraphs, Douglas, Isle of Man.
Rickard, Frederick T.	Indian Government Telegraphs.
Riemenschneider, Fredk. W. C.	Great Northern Telegraph Company, Libau, Russia.
Rippon, J.	India Rubber Company, Silvertown, E.
Roberts, Martin F., F.C.S.	Postal Telegraphs, Gloucester Road, N.W.
Rogers, F. M.	29, Moorgate Station Buildings, E.C.
Rogers, G. F.	5, Great Winchester Street Buildings, E.C.
Rope, L. W.	Anglo-American Telegraph Company, Brest.
Ross, John	5, Logie Bank, Lochie Road, Dundee.
Ross, Walter O.	West India and Panama Telegraph Company, St. Thomas, West Indies.
Rowe, Thomas	Pointsman Inn, Whitelands Road, Stalybridge.
Ruddle, Mark	Edison Electric Light Company, 57, Holborn Viaduct, E.C.

Rushton, William S.	General Post Office, E.C.
Russell, Frank	5, Trafalgar Court, Brighton.
* Sale, M. T., Major, R.E., C.M.G.	Yarmouth, Isle of Wight.
Sandeman, Colonel J. G.	24, Cambridge Square, W.
Saunders, J. B., Junior	Messrs. J. B. Saunders & Co., Cardiff.
Sax, Julius	108, Great Russell Street, W.C.
Scaife, James	Relay Office, Postal Telegraphs, Haverfordwest.
Schaefer, Louis	Eastern Telegraph Company, Malta.
Scotland, James	Anglo-American Telegraph Company, St. Pierre, Newfoundland.
Scott, J. H.	Nutsford Vale Rope and Wire Works, West Gorton, near Manchester.
Segrave, William	Eastern Extension Telegraph Company, Flinders, Victoria, Australia.
Sellon, John S.	The Hall, Sydenham, S.E.
Sennett, Alfred R.	Seacroft, West Worthing.
Sharples, C. H.	7, Fishergate, Preston.
Shaw, Lieut.-Col. W.	Darmstadt.
Shepherd, F.	Postal Telegraphs, Moorgate Street Buildings, Telegraph Street, E.C.
Shorrock, L.	Eastern Extension Telegraph Company, Bolinao, near Manila.
Simmons, Charles J.	56, Leverton Street, Kentish Town, N.W.
Simpson, George	Indian Government Telegraphs, Mannar, Ceylon.
Simpson, G. P., B.Sc.	Messrs. Siemens Bros. & Co., 12, Queen Anne's Gate, Westminster, S.W.
Slater, William	Western and Brazilian Telegraph Company, Para, Brazil.
Smibert, George	Telegraph Department, Melbourne.
Smith, A.	Indo-European Government Telegraphs, Persia.
Smith, F. J.	Mary Street House, Taunton.
Smith, John	Inspector of Telegraphs, Cape Town.
Smith, Frederick	Caledonia Iron Works, Halifax, Yorkshire.
Smith, A. Toulmin	Selborne Chambers, Chancery Lane.
Smith, W. O.,	Messrs. Elliott Bros., 101, St. Martin's Lane, W.C.
Somerville, George J.	134, Buccleuch Street, Glasgow.
Spagnoletti, J. E.	The Poplars, Aberdeen Place, Maida Hill, N.W.

Spratt, G. O.	Eastern Telegraph Company, Porthcurno, Penzance.
Squier, J. E.	Eastern Extension Telegraph Company, Hong Kong.
Squires, Frederick	Anglo-American Telegraph Company, Brest.
Squires, George	Anglo-American Telegraph Company, St. Pierre, Newfoundland.
Stacey, George B.	Eastern Telegraph Company, Bombay.
Standford, W.	Telegraph Department, Cape Town.
Starke, Henry	Government Telegraph Department Brisbane, Queensland.
Steet, G. C., F.R.C.S.	130, King Henry's Road, Hampstead.
Stevens, Frederick P.	Port Darwin, South Australia.
Stevens, Henry	Port Darwin, South Australia.
Stevenson, Ed. Alf.	Telegraph Construction and Maintenance Company, Enderby's Wharf, East Greenwich, S.E.
Stevenson, George	Eastern Telegraph Company, Alexandria, Egypt.
Stewart, D.	Postal Telegraphs, Glasgow.
Stockdale, Lawson	Telegraph Department, L. & N. W. Rly. Company, Preston.
Stokes, Henry L. S.	15, Hollywood Road, West Brompton, S.W.
Stone, William H.	Department of Public Works (Telegraphs), Tokio, Japan.
Stopford, Major J. G. B.	Duke of Cornwall's Light Infantry, Aldershot.
Stout, Robert	Postmaster, Lerwick, Shetland Isles.
Straube, Albert A. L.	12, Queen Anne's Gate, Westminster, S.W.
Stringer, E. B.	101, St. Martin's Lane, W.C.
Strauss, Frederic	Emden, Hanover.
Stuart, J. D. B.	French Cable Company, North Eastham, Cape Cod, Mass., U.S.A.
Sullivan, Herbert W.	Norfolk House, Westwick Gardens, West Kensington Park.
Swemmer, B.	Government Telegraphs, King William's Town, Cape of Good Hope.
Tansley William	Postal Telegraphs, Portarlington.
Tapp, George R.	18, Queen Margaret's Grove, Mildmay Park, N.
Taylor, Frank A.	Eastern Telegraph Company.

TAYLOR, HENRY	Coatzacoalcos, care of F. T. Van Valkenburg, Esq., Mexican Telegraph Company, Vera Cruz, Mexico.
TAYLOR, WILLIAM GRIGOR	Eastern Extension Telegraph Company, Sydney.
TEALE, WALTER	
THWAITES, JAMES	25, St. John's Street Road, Clerkenwell, E.C.
THEILER, RICHARD	86, Canonbury Road, N.
THOMAS, G.	Brazilian Submarine Telegraph Company, Pernambuco.
THOMPSON, F. O.	Direct United States Cable Company, 58, Old Broad Street, E.C.
THOMPSON, HAROLD LYON	74, Onslow Gardens, S.W.
THOMSON, JOHN H. S.	United Telephone Company, 36, Coleman Street, E.C.
THORNTON, F.	Messrs. Clark, Muirhead & Co., 29, Regency Street, Westminster, S.W.
TILLY, G. B.	Eastern Telegraph Company, Gibraltar.
TONKING, RICHARD	78, Lorne Terrace, Annandale Road, East Greenwich, S.E.
TOPPING, F. W.	Direct United States Cable Company, Ballinskelligs.
TRANFIELD, F. T.	Anglo-American Telegraph Company, Valentia, Ireland.
TRIPPE, C.	Anglo-American Telegraph Company, Heart's Content, Newfoundland.
TUBB, ALBERT	Postal Telegraphs, Southampton.
TUCK, W.	Eastern Telegraph Company, Suez, Egypt.
TUFFIELD, T. S.	Agencia de l'Empresa, Telegrafo Submarine, Arica, Peru.
TUNBRIDGE, W. T.	London and North Western Railway, Stafford.
TURNER, W.	31, Malpas Road, Lewisham High Road, S.E.
TYLER, W. J.	106, Cannon Street, E.C.
UPTON, HENRY	Marlborough Club, Pall Mall, S.W.
UREN, GEORGE G.	Eastern Extension Telegraph Company, Penang, Straits Settlements.
URQUHART, DAVID	4, The Sanctuary, Westminster, S.W.
VANE, FREDERICK W.	General Post Office, Colombo, Ceylon.

VARLEY, CROMWELL O.	10, St. Peter's Street, Ipswich.
VENNDT, C. F.	Great Northern Telegraph Company, 119, Bishopsgate Street Within, E.C.
VERE DE VERE, ARTHUR	Eastern Telegraph Company, Constantinople.
VERNEY, Captain, R.N.	Rhianva, Bangor, North Wales.
VESEY, ARTHUR H.	"The Grange," Knockholt, Kent.
VOLK, MAGNUS	40, Preston Road, Preston, Brighton.
VON DONOP, P. G., Lieut., R.E.	31, Park Street, Bath.
VYLE, SAMUEL	22, Borough Road, Middlesboro'.
WALDUCK, CHARLES E.	148, Gresham House, E.C.
WALKER, WILLIAM K.	Rangoon.
WALROND, T. C. T.	11, Rockley Road, West Kensington Park, W.
WARNER, R. A.	Cassilla, No. 777, Buenos Ayres.
WARREN, J. D.	1, Harwood Road, Walham Green, S.W.
WARREN, WILLIAM (*Honorary Secretary for Tasmania.*)	George Town, Tasmania.
WATKIN, H., Capt., R.A.	Royal Gunpowder Factory, Waltham Abbey, Essex.
* WATSON, C. M., Capt., R.E.	Store Department, India Office, S.W.
WEATHERALL, T. E.	Telegraph Construction and Maintenance Company, Greenwich.
WEAVER, A. C. M.	Eastern Extension Telegraph Company, Singapore.
WEBB, F. H. (*Secretary.*)	9, Bernard Street, Regent's Park Road, N.W.
WEBBER, T. B.	Telegraph Department, Great Western Railway Company, Plymouth.
WEBSTER, J. K.	Anglo-American Telegraph Company, Brest.
WEEDON, E.	Anglo-American Telegraph Company, Heart's Content, Newfoundland.
WHITE, ARNOLD	Edison Electric Light Company, 57, Holborn Viaduct, E.C.
WHITE, F. H.	Anglo-American Telegraph Company, St. Pierre, Newfoundland.
WHITMORE, MORTIMER, Captain, R.E.	Postal Telegraphs, Walpole Street, New Cross, S.E.
WHITAKER, J. E.	Inspector, Lancashire and Yorkshire Railway, Halifax.
WHITTINGBACK, C. H., Sergt., R.E.	Indo-European Government Telegraphs, Sivand, Persia.
WIGAN, GORDON	2, Brick Court, Temple, E.C.

WILDE, EDWIN . . .	. Postal Telegraphs, Doncaster.
WILKINSON, HENRY D. . .	. Eastern Extension Telegraph Company, Penang, Straits Settlement.
WILLIAMS, A. G. . .	. Anglo-American Telegraph Company, Heart's Content, Newfoundland.
WILLIAMS, J. . . .	. Indo-European Government Telegraphs, Persia.
WILLMOT, JOSEPH . .	. Postal Telegraphs, General Post Office, E.C.
WILMOT, T. J. . . .	. Direct United States Cable Company, Rye Beach, U.S.
WILSON, . HC. . . .	. Superintendent of Government Telegraphs, Kingston, Jamaica.
WINDELER, HENRY . .	. Anglo-American Telegraph Company, Valentia, Ireland.
WINTER, C. E. . . .	. Upton Cressett Rectory, Bridgnorth.
WISELY, G. A. K., Lieut., R.E.	. Government House, Nicosia, Cyprus.
WOOD, Major ALEXANDER .	. Abbey Wood, Kent.
WOODCOCK, W. . . .	. Anglo-American Telegraph Company, Heart's Content, Newfoundland.
WOODS, JAMES W. . .	. Engineering Department Postal Telegraphs, Oxford.
WRIGHT, ARTHUR . .	. 66, Grand Parade, Brighton.
WRIGHT, JAMES . . .	. Messrs. Siemens Bros. & Co., 12, Queen Anne's Gate, S.W.
WRIGHT, THOMAS . .	. The Eastern Telegraph Company, Malta.
YEATES, HORATIO . .	. 33, King Street, Covent Garden.

Total Number of Associates . . . 532.

STUDENTS.

Ansell, Harold W.	Kildermorie, Merton Road, Wimbledon
Barclay, L. D.	33, Culford Road, Downham Road, Dalston, N.
Brackett, Arthur Wm.	21, London Road, Tunbridge Wells.
Bright, Charles	31, Golden Square, W.
Brooks, Edwin M.	2008, Chestnut Street, Philadelphia, U.S.A.
Davies, George L.	
Kennelly, A. E.	Eastern Telegraph Company, 66, Old Broad Street.
Lewis, Robert	"Fairlight," Croydon, Anerley, Surrey.
Scott, Montagu J.	16, Church Row, Hampstead, N.W.
Stallibrass, Edward	31, Golden Square, W.
St. George, A. F.	Montagu Villa, Redhill, Surrey.

Total number of Students 11

TOTAL NUMBER OF MEMBERS.

Honorary Members	5
Foreign Members	170
Members	366
Associates	532
Students	11
Total	1,084

JOURNAL

OF THE

SOCIETY OF

Telegraph Engineers and of Electricians.

Vol. XI.	1882.	No. 40.

The Hundred and Sixth Ordinary General Meeting of the Society was held at the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday evening, January 19th, 1882—Professor G. C. Foster, President, in the Chair.

The minutes of the previous meeting were read and confirmed, and it was announced that the following transfers had been made by the Council:—

From the class of Associates to that of Members:

Edward Cox-Walker.
William Ninnis Tiddy.

From the class of Students to that of Associates:

Basil Gee.
George Annesley Grindle.

The President: Before going further with our proceedings, I have to announce the loss by our Society of one of its earliest and most distinguished members, Mr. Louis Schwendler. In connection with the decease of that gentleman, the Council have passed the following resolution, which I have no doubt will receive the approval of every member of the Society:—"The Council have received with much regret the announcement of the recent death of Mr. Louis Schwendler, and cannot let the occasion pass without expressing their sorrow at the loss of so distinguished an electrician,

and such an active member of the Society." I feel sure that the Society at large will wish to be associated with that resolution.

The PRESIDENT: I have further to announce that the Society has received, since the last meeting, a very valuable gift from Mr. G. J. Symonds, President of the Meteorological Society, in the shape of a collection of books on atmospheric electricity, especially in connection with lightning and thunder-storms. I know I shall express the wish of the Society in proposing a vote of thanks to Mr. Symonds for his present.

A vote of thanks was accorded to Mr. Symonds with applause.

The PRESIDENT: My only further duty in this chair is—to get out of it; and, in retiring from office, I have very great satisfaction in thinking that my successor will be one of the founders of the Society. The past year has been in some respects a memorable one in the history of the Society, and I cannot but wish that during this period you had been represented by a more efficient President; but still, my connection with the Society, and the closer intercourse into which I have been thrown with many members, has been to me a source of very great pleasure, and I can wish nothing better to Lieut.-Col. Webber than that his year of office may be to him a source of as much satisfaction as mine has been to me.

Lieut.-Col. C. E. Webber, R.E., President-elect, then took the chair.

Mr. W. H. PREECE, F.R.S.: Sir,—I am very pleased to think that the first duty you will have to discharge is in reference to a resolution which it will, I have no doubt, afford you as much pleasure to put to the meeting as it affords me to propose, viz.: "That the best thanks of this Society be given to Professor Foster for the able manner in which he has performed the duties of President during the past year." Professor Foster cast some doubt upon his own efficiency; but if incessant attention, if a full and thorough discharge of duties, not only as President, but as member of Council and member of Committee, constitute efficiency, then I think that Professor Foster may congratulate himself upon having been the most efficient President that we have ever had. At great personal inconvenience to himself he went over to Paris, and there

presided over our meetings with a great deal of *éclat* to himself, which was reflected on the Society itself, through having at its head so distinguished an electrician and physicist as Professor Foster. I have great pleasure in proposing the vote of thanks to Professor Foster.

Professor W. G. ADAMS, F.R.S.: I have very great pleasure indeed in seconding the vote of thanks to Professor Foster, but after the able remarks of Mr. Preece it is not necessary for me to add many words in support of his proposition. We all know the zeal which Professor Foster has displayed, and the attention which he has given to the work of President during the year, and I need not take up the time of the meeting by enlarging on it, but will only repeat that it affords me very great pleasure to second the proposition.

The vote was carried most heartily.

Professor G. C. FOSTER, F.R.S.: I can only thank you sincerely and heartily for the kindness of the vote which has just been passed, and for the support which I have received throughout, in every way, from every member of the Society with whom I have come into contact. If the past year has been successful, it has only been through the efficient co-operation of my colleagues. I considered myself, as the servant of the Society, bound to carry out, to the best of my ability, the wishes of the Society at large; and I am very glad if you have been in any degree satisfied with the services that I have been able to render.

Lieut.-Col. C. E. WEBBER, R.E., then read the following:—

INAUGURAL ADDRESS.

By Lieut.-Colonel C. E. WEBBER, R.E., President.

January 10th, 1882.

The commencement of the second decade in the life of a Society in which many of us have been for so long interested, even from its birth onwards, is passed, and we are already in its first year. It is hoped that we shall not be considered by our visitors to transgress the bounds of fitting modesty, if mutual congratulations are allowed to-night to mingle with the more

serious task of stocktaking of our present and future position, which each year seems to be incumbent on your newly-elected President.

That the task has fallen to my lot is not the result of any merit that I am conscious of. That your suffrages have placed me here is my encouragement and only support in so serious and responsible a position; doubly reassuring when I recall the roll of very illustrious predecessors amongst whose names you have placed so humble a one as mine. That I owe this eminence to anything in myself has never entered my thoughts; but rather do I feel I owe it to my intimate connection with the birth of our Society, since which time, especially during its infancy, I have been fortunate enough to continue in its service. But when I recollect the eminent services which were rendered by Lieut.-Col. Bolton, Dr. Siemens, Mr. Sabine, and others, when the notion of forming such a society was first broached, all that I may have done at that time sinks to insignificance.

If, then, you will permit me to feel that your choice has this year fallen on me simply because you wish to give honour to old service, I shall reconcile myself to a position to which I have no title but your consideration, except, perhaps, that of love for the science which is our common object, and loyalty to the Society, the business of which has brought us together this evening.

The peculiar difficulties of our early years may not be known to many, but it will be remembered by the small knot of persons gathered in a back room not far from this, in the summer of 1870, to discuss the possibility of founding such a society, that but scant encouragement appeared in view. Mr. Latimer Clark could tell you that, while offering his warm and genial personal sympathy for the movement, little hope of success dawned in his mind.

To the warm encouragement then forthcoming from those whom I have named, and from several others equally well known to you, is due the foundation of the Society of Telegraph Engineers. It shows that they had not been disappointed by the failure of previous efforts in the same direction, one of which, by Mr. Sabine, it is now only just to mention. To that gentleman is, I believe, due the idea of forming an electrical society, he having a few years

before commenced such an organisation, which only failed to incubate, probably, because the time was not then ripe for such a birth.

In fact, the year 1870 was a momentous one in the history of the applications of electricity in this kingdom. The founders of this Society, using the name in the larger sense, hit on the lucky moment which was heavy with great change. The star of telegraphy was in the ascendant, a great stimulus was given to its extension by the Government purchases, and the name of Telegraph Engineer had begun to take a place in the front rank, not only through the force of numbers, but through the real weight of success already accumulated by its earliest possessors.

That our Society then supplied a want, and did not create it, has been patent at each stage of its subsequent life.

Our members and associates are enlisted from every source. We include comrades in the service of the postal telegraphs, in all the railway companies, in the submarine telegraph companies, in the great manufacturing firms, in the electric light companies, in the Indian state telegraphs, and in the colonial administrations; amongst the most eminent scientists at home and abroad, in the navy and army; and prominently are we connected with other nations, as may be seen by a glance at our long list of foreign members.

I do not think I am wrong in believing that one of the first causes of our success, so far, has lain in the principles upon which the Society was founded. These were *liberality* and not exclusiveness. *Liberality* in the widest sense was our motto. We desired to gain the adhesion of all persons scientifically and practically interested in the study and application of electricity, and in spite of our title, which apparently tended to exclusion, we managed to attract and collect within our fold, a large proportion of the most prominent men connected with the subject. The secret of this lay, I submit, to a great extent in the liberality of our constitution. The success which early characterised our meetings was due to the variety of minds which was comprised in the attendance.

I well remember at one of them, the late Colonel Home, C.B., asking to become an associate, on the ground that he had been to

the meetings of no society at which he had encountered such a practical tone in discussion.

An early duty of this Society was to keep alive the interest in electrical subjects. The natural consequences of the great monopoly of the state telegraphs were, that the trade and business of private enterprise became depressed. The Post Office, however, became a rapid consumer of telegraph material, and submarine cable factories flourished as the increased incentive to the use of internal telegraphs, produced by the rapid extension of lines, reacted on international and colonial traffic.

It is not too much to say that the papers and discussions at our meetings did a good work in the advancement and promotion of the labours of the state telegraphs. At them subjects were freely canvassed which were of great importance to the extension of the telegraph system to meet the increasing wants of the public. Experiences gained in the public telegraph service were communicated to us, and these again gave rise to counter announcements which brought to light practical knowledge which was useful to all.

Inventions which might have been inconsiderately adopted or inadvertently neglected have been shown and discussed here, and their real merits or defects suggested. A great responsibility of telegraph administrations everywhere lies in their duty of fathering inventions. The inventor may be one of their employés or not. In either case, once pledged to the expense of trying or adopting an instrument, they are very slow, for financial or other reasons, to admit an entire or partial failure.

It has been seen in several countries that persons high in authority, without thorough practical knowledge, but fascinated by an invention, have committed themselves to it, and, in consequence, the operations of a national administration have been crippled in the future.

Their motive—desire to encourage invention—is, no doubt, excellent, but it may be carried too far; and large sums may be spent in the purchase of patents or in the promotion of improvements, by carrying out experiments which a free discussion before an assembly containing practical men, like ours, would have shown

good reason for pausing on, or altogether avoiding. I wish to deprecate, also, parsimony in an administration in this direction. Valuable improvements may be lost, or the profitable use of them postponed, for want of wise expenditure.

The history of this subject, followed through the papers read at this Society's meetings, appears to point to the best results having been obtained when decision has been guided by true commercial principles.

The competition for efficiency in telegraph transmission is not international, as in the case of artillery, in which the work of one year's trials may have to be thrown aside, and fresh expenditure undertaken, because another nation has made an important advance.

In telegraphs, what each country has to do is to keep up to the demands of its public, always remembering, for its own protection, that once it has accustomed that public to certain facilities or conveniences, they cannot easily be withdrawn, especially if they tend to cheapness.

For instance, once type-printed telegrams are issued by an administration, it will be very difficult to withdraw them. Their use by the United Kingdom Telegraph Company in England does not seem to have injured the business of the other companies which did not employ that means; but the business acquired by the former company during the period of its existence was a partial measure of the actual estimation of the public of the type-printing system.

Its abandonment by the Post Office has proved to have been a wise step, and shows the value of the advice under which the Postmaster-General came to the decision. The effort to meet a demand for type-printed messages in the United Kingdom would have been fatal to the extension and the cheapening of the telegraph service, on account of the heavy expenditure in apparatus and high-class labour which must have followed.

Its extension in countries which are obliged to be satisfied with what bureaucracy sees fit to grant to the public, is limited to first and second class lines; but there is equal reason for adopting the system for all lines and stations, and the British public is one which is notorious for liking sauce to its goose as well as to its gander.

Technical societies are of more value in giving opinions on such

points, as my example above refers to, than International Exhibitions. At the latter, each nation ought to be able to put its own experience to a practical test, with the assistance of other experiences. Unfortunately, there are very few visitors to exhibitions who really appreciate more than they actually see and most are led by the reports, which are extensively spread, in favour of this or that invention—more dependent on the manner of exhibiting it than on its practical value.

It is to be feared that the work of Juries is rather unpractical in this respect, and that this is so well known, little attention would be given to their decisions in the discussions at such a society as this. This view is not altogether undeserved: the work of jurors, when scientific instruments are concerned, is so difficult, that it is not unfair to doubt their ability to discriminate. I believe that if the deliberations of the Juries lately convened at Paris were made public, it would be found that, while every desire was shown to be fair, certain foregone conclusions were invariably adhered to, and that any argument which set them aside had to be abandoned. It is no spirit of depreciation of the work of the eleven English gentlemen* who so patriotically came forward and acted as jurors for the Electrical Exhibition at Paris which induces these remarks. My own experience in 1878 makes me believe that, while none regretted accepting the office, few completed their toil with entire satisfaction; but we, as a society, may well this night record our pride at their loyalty and devotion in thus gratuitously undertaking so arduous a task for the honour of their country and for the credit of this Society.

To a society like ours the telegraph administration of the United Kingdom owes some gratitude for taking from its shoulders a part of the burden which in France appears to have been taken up by the Ministry of Posts and of Telegraphs. The latter sets an example of a practical effort to encourage invention or improvement amongst their officers. Not only do they give real assistance in money, but they also attach the inventor's name to the invention.

* Eight of whom are members of the Society of Telegraph Engineers and of Electricians.

No one can doubt the value of encouragement of this sort, when it is judiciously dispensed. Its absence leaves a very large number of persons hopeless of any honour or advantage if their genius leads them to suggest or adopt practical improvements in their daily work. The absence of this in a State department is, no doubt, convenient, and not a source of mischief, when all those who are in earnest to shine become attached to a public body such as our Society. It is true, and cannot be avoided, that men with higher powers than their fellows merely give the mean result of their efforts to their daily toil, and glean every moment of their spare time to advance their own private interests outside the range of their actual duty.

But while the legitimate safety valve of the publicity given here continues, the administration need only guard against the effects of being satisfied with mediocrity. Such content will not tell in one generation; a low standard of intelligence has always a tendency to get still lower, and without the tradition of encouragement to talent within the public service itself, no incentive we can here give will avail.

Ten or twelve years ago the applications of electricity began to find a place in the conduct of War, and the subject began to make itself felt in the military world, and many naval and military officers found in this Society a means of instruction and discussion, since which time their numbers have been steadily on the increase.

The use of electricity for Military Telegraphs, and the many appliances in use for that purpose, have been a frequent subject of discourse at our meetings, with no small benefit to the public service. Questions which could never have been raised officially have been calmly discussed here, and practical objections to theoretical inventions have been freely ventilated, so that the authorities have benefited by the criticism that has thus been brought to bear on crude proposals, which, however plausible, would have been detrimental to the service.

From experience gained here and abroad, the subject is by no means exhausted, and much is still left to be told which would be of great general interest.

There is no want of interest in the Society's proceedings on the

part of those who are qualified to tell us the story of the difficulties and vicissitudes of several years in practical experiment, so as to render the Torpedo service of the country, both offensive and defensive, as efficient as it is now believed to be. This warlike application of electricity has, unfortunately, never been described before the Society.

Those qualified in the subject, who could give us some of the most interesting papers on it, feel that every stage of such a recital would be a betrayal of information which could not be safely made in the interests of the nation. If our naval and military comrades have hitherto been silent, we must give them credit for the best intentions, and we must trust that their labours have long ago placed the nation ahead of all others in the application of electricity to Submarine Mining.

But perhaps their enforced silence may be broken before long, so that, without divulging State secrets, something of the nature and results of their experiments may be made the subject of papers and communications of general interest. And those officers might be reminded that no harm would be done if they would favour the Society with accounts of the foreign systems which from time to time pass under their notice.

There is one branch of the subject which is open to the investigation of all, and which at present is a good deal in the shade. Apparatus has yet to be invented which, with the aid of electricity, will detect and record the effect of the effort of submarine explosions in all directions, with reference to the depth of the water. Important knowledge in this respect has still to be collected, especially in connection with the vibration of the mass, whether of water around, or of the denser earth forming the floor of the mine field. The laws governing the results and effects of explosions are at present little known, and as the effective force of explosives is daily becoming a matter of vital interest, all investigations connected with submarine explosions will be of assistance, owing to the almost unlimited scope for practical experiment afforded by operations carried on in the sea.

At present electricity is used much on board those wonderful mammoth fighting monsters, our newest iron-clad battle ships; it

is used as means of communication, as means of explosion, and as means of lighting not only the interior of every part, but also as means of shedding daylight round the vessel in her nightly course. From what I have seen of these applications, I have been struck, perhaps mistakenly, by the apparent want of practical knowledge shown in the constructions; and, considering how little known in the scientific world are the persons charged with the work, it has often seemed to me that publicity as to these wants and applications might very much benefit the Naval service, if these inventions were discussed and ventilated at our meetings. At any rate, our Society could not fail to benefit in some way by the knowledge and experience of the officers and gentlemen whose source of means of training is at present unknown to us.

As I have said, liberal principles were the mainspring of our organisation. While many of our members claimed to be Telegraph Engineers, they gladly saw their ranks joined by others who could not exactly apply that name to their occupations; and every one who interested himself, either professionally or as amateurs, in the uses of electricity, was warmly received into our list of associates.

The Society was not formed for the purpose of conferring a diploma so much, as to bring together, under the auspices of a common parent, all men whose minds were searching for the light in a common direction. The Society has sought to bring together and associate all men having a common object, whether the worker in the telegraph office or in the scientific shop. Here they meet the scientist from his laboratory, the manufacturer, the engineer, each ready to learn or to impart knowledge. Here come men whose experience has been gained on railways, at sea, in war, or in the telephone office, the only qualification being that each has grasped the true meaning of the wonderful agent he employs. Whether in his desire to learn or to teach, each finds here a place where he can ventilate his ideas, so that he is often saved disappointment, annoyance, and expense, by having them first subjected to the friendly criticisms of his fellow-members. In this lies the liberality of our Society, that the platform of our qualification for membership and association is as wide as the field of application and use of electricity —a field which, we are daily realising, embraces all nature, on the

margin of which our baby experiments have only as yet given us a foothold.

Our subscriptions have hitherto been so small in comparison with other Societies, that had it not been for the early liberality of some of our principal Members, and the honorary services of our Secretary, Treasurers, and liberal Legal Advisers and Auditors, the Society might not ere this have cleared the cape of financial difficulties which first threatened its course.

I do not believe that the liberality of our franchise in the case of Associates, who form our greatest constituency, will ever injure our progress. In this very matter we have been imitated by our great parent in whose halls we assemble, who has in the last few years taken a "wrinkle" from us, and greatly widened the area of qualification required for admission to the position of Associate of the Institute of Civil Engineers.

While dwelling on this subject, I want to bring before your notice a direction in which we ought to reach and try and induce an accession to our ranks of many names of the professions which are devoted to the cure of our bodies. There is not one of us, probably, who has not the opportunity of bringing the advantages of the Society before friends in those professions. We ought no longer to allow their absence; there is much no doubt for us to learn from them; but is not the day rapidly advancing when the study of electricity in its physiological functions will form the most important base of the knowledge to be acquired by a medical man, and when the knowledge of such Frenchmen as Desjardins will no longer be looked down on by the pharmaceutists? I would that this year should not close without our having such names as Burden Saunderson, Ferrier, and Yeo, and many others, added to our membership. The Electrical Congress at Paris has set an example in this respect, by the discussions in the commission of electro-physiology, in which Helmholtz, Du Bois Raymond, and D'Arsonval took part, on the 22nd and 23rd September last. The publication of these will, it is hoped, lead many men engaged in the work to find some benefit from association with a Society which possesses in its ranks men celebrated for their knowledge of electricity, and which is in alliance with electricians all over the world. Our Society is eager

for knowledge on the subject of electro-physiology, and we are now ripe to receive papers which would even place us on a level with the principles and natural laws, as yet discovered, of the action of electricity as a vital agent in physiology, as well as of the application of the same agent externally, as a means of arrestation of decay, or of restoration of deficient vitality.

I cannot conclude reference to this branch of the subject without mentioning a most interesting communication of Dr. Stone, made a few weeks ago to the British Association, which might well make its first appearance in our Journal. It is on the use of the continuous current in diabetes, by Drs. W. H. Stone and W. J. Kilner. Remarkable effects are recorded of the use of a current of 2,000 microwebers from a battery of 30 bichromate cells, the positive pole being in contact with the forehead, the negative with the nape of the neck. So interesting is the account, that one instinctively feels there remains a wide field of investigation still untrod, both for practitioners and physiologists.

Before dismissing the past from your minds, it seems well to recall to you how the birth of this Society supplied a want, and in a most salutary way has released men's minds from doubts and difficulties, the continuance of which were dangerous to the real interests of true science. I mean the freedom of discussion at our meetings, which brought rash statements to the test, and elucidated the truth on questions which had previously been a matter of doubt. For instance, electricity applied to telegraphy had in the previous 30 years been the chief means of advancing the knowledge of the science in its practical form, and a large number of inventions had been the result. Distinguished inventors had simultaneously brought out the same adaptations, or discovered the same principles; some were taken up, and some not; as time wore on, others had built on their work. There was no Du Moncel to record in a fresh publication the plagiarism or the originalty of each new announcement. Many remember our early discussions, when these questions were amicably discussed, and when the truth was so quickly established that contradiction was not necessary, and honour was rendered without question where it was due; when false claims were quickly and easily refuted, and when earnest men

who have missed the fruits which their labours should have brought them, have left our meetings at any rate satisfied that their just claims to priority have been recognised. The very absence of differences of the kind at our meetings of late years shows how men's minds are satisfied, and the acknowledgment of the early labours of the patriarchs of the science, dead and living, has brought us the reward of finding the latter amongst the first to accord credit to the rising generation of inventors, and the best to criticise efforts, as regards which they have no jealousy, and on which their experience enables them to pronounce the most impartial opinion.

If this feeling, the existence of which I boast, is not by chance existent in any mind, I would offer them the pledge of the Council of your Society that every new idea, every originality, every study of past work, every fair criticism, every description of the work of others, will be considered on its merits, without reference to any interests, commercial or otherwise. We believe that this character for consistency and purity of intention has been won, and that we shall ever maintain it; and we therefore call upon all who feel aggrieved at any time, as to the want of publicity of their claims, to appeal to the free discussion afforded in the arena of our meetings.

The Society has already taken the initiative in establishing the priority of claimants, by publishing the work of Lieut.-Col. Bolton, who, with considerable labour, in 1878 brought together facts connected with electric light patents—a work which has been so well followed up by our librarian, Mr. Frost.

The historical collections at the Paris Exhibition have been of great interest to those who care for the archæology of science, and tend to show the advantage of accurate knowledge of what has gone before us. The collections probably included everything of the kind which Europe could produce, from the early practical uses, exhibited by the State Telegraph Administrations, to the experimental apparatus shown by universities and scientific bodies.

The exhibition of Pacinotti's ring in the Italian section brought home to the minds of the army of inventors how long ago the present form of continuous-current electro-motors had had its birth. The Society had the honour of hearing an explanation of this original machine from the lips of the well-known Prof. Govi, at its

meeting in Paris in September, at which meeting Signor Pacinotti himself addressed us—a memorable occasion in our annals, and one to be long remembered by those present. For an admirable narrative of the Pacinotti ring, I would refer my hearers to Mr. Conrad Cooke's description in *Engineering* of the 18th November, 1881.

This may be also a good occasion to refer to the distinguished work of the late Doctor Gloesener, Professor of Physics at the University of Liege, to whose memory the Congress at Paris desired to give honour by the admission of his daughter as the only lady member.

An original manuscript of his, dated 20th April, 1842, was exhibited amongst the Belgian historical collection, in which he describes electro-magneto, oscillating, and rotatory motors invented by him, and described as "destined to take the place of steam and other motors."

In this description Doctor Gloesener states that he obtained better results from oscillating than from rotatory motion, and claims to be the first to propose such a motor. In his printed electro-dynamic studies, published in 1873, he describes the system in detail; but the manuscript of 1842 is so clear that it stands by itself, and no one can say that the later publication detracts from the originality of his proposals at the earlier date. Later he abandoned his claims to superior advantages attached to oscillation, and long before 1873 his difficulties with batteries as originators had been conquered by Ladd, Wylde, and many others.

From the same series of manuscripts there is ample proof that as early as 1837 Gloesener had discovered the advantages of the use of the double-current systems of telegraph transmission, as he expresses it, "for the suppression of the use of springs to armatures." This system was afterwards applied by Mr. Cromwell Varley in his double-current system, with relays and keys, used in the service of the Electric Telegraph Company, and still unrivalled for use in any country subject to the variability of our climate. Gloesener's views and experiments have also been beautifully exemplified in Siemen's polarised relay, and in his military Morse recorder.

These manuscripts are also authenticated by having been in the possession of public bodies in Belgium since the dates when they

appeared, and having been exhibited under their authority at Paris. I have myself examined those I mention, and also others, on the relation of magnets and electro-magnets in combination, addressed to the Academy at Brussels and other Belgian scientific societies, dating from so early as 1822. It is most striking that hardly any of the applications in telegraphy and in dynamo-electricity, now well known, are not described or foreshadowed by the versatile genius of Doctor Gloesener.

There are probably few here who have not been aware that a Lightning Rod Conference closed its sittings in August last. The report of the delegates, edited by the secretary, Mr. G. J. Symonds, F.R.S., has just appeared. After a cursory perusal of the volume, I think it is a matter of congratulation to the Society of which we are members or associates, that out of twelve delegates six belong to our body.

The report is an admirable record of the united opinion of ten members of the Conference. In nineteen pages, all that is necessary to describe the plain laws of lightning conductors, their uses and features, are clearly and simply stated. No one, even a tyro, rising from reading it, could fail to understand its plain definitions and descriptions; and no critic can find that there has been any omission to accept all just conclusions from the mass of literature and contributions which have been quoted as having aided the assembled delegates in drawing up their report. The remainder of the volume comprises many original communications and many extracts from others. A list of over 700 publications in various languages on the same subject is added, showing the large share of attention the subject has had during the last two centuries. The excellent plan adopted by the Editor places the student in a position to pursue his studies of the subject to any extent; while the general public must feel quite assured that there can remain no doubt as to the proper method of protection against lightning in all its phenomenal displays. Even if the examples quoted give no idea of the torrents of discharges witnessed in sub-tropical regions, every conclusion come to, every rule laid down by the Conference, is equally true and applicable.

My reference to Mr. Symons' labours on the valuable volume I

have described, recalls that gentleman's late act of munificence of which our Society has been the object. You will learn from the valuable annual report of our librarian, Mr. Frost, that, amongst others, we are indebted to Mr. Symons' liberality for the gift of about sixty important and valuable works on lightning and lightning conductors, which he discovered had not yet been added to our library, and which he decided on presenting, as, to quote his own words, "a slight indication of his appreciation of the good work done by our Society."

An event of great importance to science has distinguished the year 1881: I mean the International Electrical Congress held at Paris in September last, under the presidentship of Monsieur Cochery, the Minister of Posts and of Telegraphs. The members of the Congress were drawn from all nations, and numbered 241. The decree was signed so long ago as October, 1880, by Monsieur Grévy, President of the Republic, showing the intention and the weight of the authority by which it was convened, and the execution of the decree was consigned to MM. Barthélemy St. Hilaire and Sadi Carnot, Ministers of Foreign Affairs and of Public Works, as well as to Monsieur Cochery. It would be invidious to attempt to select names from the list of the members, but to give you an idea of the distinction belonging to the Congress, I must name a few. From Germany, the names Du Bois Raymond, Helemholtz, Siemens, alone distinguish a list of well-known discoverers and scientists. From Austria, that of Hermann Melitzer is sufficient as a type of Official, not easily forgotten. Of the thirty-two Belgian representatives, it would be unequal to name one before another. From Brazil, Colombia, Costa Rica, Denmark, and Spain came men all of whom had distinguished themselves in their own countries. From the United States I need but mention the name of Professor Rowland, to give an idea of the strength of representatives sent from across the Atlantic. France, it need not be said, was represented by all that is most learned and most practical in the renowned scientific world of that distinguished country. When we turn to our own United Kingdom, we may well feel proud of the voluntary labours of those friends whose names, by their inven-

tions, their discoveries, their disinterested works for the benefit of mankind in all directions, are as familiar as household words.

From Greece, Guatemala, Hungary, Japan, from the Netherlands, Portugal, Switzerland, and Russia,—each sent delegates, and last, and perhaps greatest as a man, Italy sent a Govi.

The Congress opened on the 15th September, and immediately divided itself into three sections. Under the exceptional presidence of Monsieur Cochery the work was divided so that the applications of electricity were grouped in three, and matters of minor or exceptional importance in the group of each section were relegated for discussion and intercommunication of ideas to sub-committees of the sections.

Larger matters were dealt with in full meetings of the sections, and the reports of the committees were received, further discussed, and their recommendations submitted to the vote. Finally, the result of all the deliberations was reported, and submitted to the decisions of the full meetings of the Congress.

With the exception of one day of rest as a tribute to the memory of President Garfield, the Congress, or its sections, or committees, sat three times a day, and did not complete its labours until the 5th October.

As the whole of the proceedings will be shortly in print, I shall not attempt to give you an idea of the immense importance of some of the work done, but just refer to one or two interesting questions dealt with.

One original proposal was made by a member, namely, that the Congress should record a decision, or express an opinion, that telegraph and telephone lines attached to buildings are not an increased cause of danger to them from lightning. Professor Helmholtz, Sir William Thomson, and others took part in the discussion. Monsieur Lartigue and Monsieur Béde, both interested in over-house constructions,—the one in Paris, the other in Brussels, —were warmly desirous of a favourable decision. Throughout, theory took up the question from the point of view of danger to the persons using the apparatus, or the objects surrounding it inside a house. Practice, on the other hand, was unanimous in claiming immunity from danger, if not protection, by the attachment of telegraph lines to buildings.

It would probably be accepted here that practice was not far from wrong, but on the Continent practice of this kind is very limited in comparison with the wide extension of over-house wires here and in America. The Congress therefore wisely declined to lend the weight of its authority to a question, which had probably been raised with reference to the local commerical results of such a decision.

The remarkable work of the Commission on the electric units, under the presidency of Monsieur J. B. Dumas, has been already well described in the public papers; but I may add that several members of Congress also explained the importance to electro-biology and therapeutics of having uniform standards of measurement. Monsieur d'Absonval showed what grave accidents might arise in practice for want of a thorough understanding and uniformity in this particular.

If the Congress had met and separated with but the one result, its meeting would still be memorable. The names of the members of the Commission charged with the discussion of the standards of electrical units includes thirty-one of the most notable electricians in Europe. It adopted four most important resolutions, a conclusion hardly to be expected except from men who, having sounded the depths of science, were fully able to appreciate the necessities of its practical application. In its wisdom, regarding the difficulty of reconciling conflicting views, the Congress left to an International Commission the task of deciding the length of the column of mercury the resistance of which, with a sectional area equal to one millimètre, and at a temperature of zero centigrade, shall represent the unity of resistance, one ohm.

A considerable number of the members of the Congress, while accepting the decisions arrived at, only did so provisionally, and only in the interest of the future establishment of an International Commission of a more permanent character, of which the task should be to establish the absolutely true basis of the electrical units, founded on careful scientific experiment, and on the best evidence after a close examination from all sides; and they claimed that their declaration to the above effect should be included in the report of the proceedings of the Congress.

The Congress requested the French Government to communicate with other governments, with the view of naming an International Committee for the purpose of making the necessary investigations, and of arriving at a final and absolute determination on the subject.

Another and most interesting subject was dealt with by the Congress, one which has ere now occupied the attention of our Society, namely, the observation of the phenomena of earth and atmospheric currents, with a view to collecting statistics on the same form, and over an area not less extended than Europe. The French Government undertook to move other nations, so that an International Commission should be appointed to carry out and organise the measure, and the Congress expressed its desire that in the meantime arrangements should be made to take observations simultaneously as to day and hour with those to be laid down by the International Commission during Polar expeditions.

On the subject of the gauge of wire, the Congress agreed to the general use of the millimètre for all countries, to the exclusion of other gauges. Perhaps this announcement at our meeting may have the effect of inducing telegraph engineers to drop by degrees the use of the Birmingham and other wire gauges, in which direction a beginning might be made, by all large consumers using millimètres in the wording of their specifications.

The attention of the Congress was drawn to the importance of the conditions of cultivation of the trees yielding gutta percha. This is a subject which may well interest members of our Society, in view of the great increase in the demand for electric lighting alone, which has resulted in a large rise in the price; but also in view of what is more startling to those who have had long experience in the use of gutta percha, the fact, that, while the best samples have more than doubled in market value, the mixtures have gone up but moderately.

MM. Menier, who in four years have created a well-appointed cable factory near Paris, have early realised the necessity of looking well ahead in this matter, in view of the rapid exhaustion of the supply which must ensue for want of even the restrictive laws which are intended to protect the india-rubber trees in Brazil.

They wished to bring the collection of the product under their own control within an area in one of the French colonies throughout which they have bought up the right. The experiment has proved to them that any real protection and conservancy of the trees can only be effectual when undertaken by Governments or by very powerful Companies. Their own acquisition has been of little value, except for experimental purposes, on account of the impossibility of excluding native trespassers in search of the product.

A suggestion emanating from this Society might promote an organisation which would be under the control of the great consumers at home. English industry is ever alive to such openings, no matter how vast the scale or how large the capital required, when it can be shown that the return in the future is sure. For years those who knew enough to anticipate a gutta percha famine have been striving to find a substitute, and the result has ever been a practical failure. It is therefore, I believe, time for such a Society as ours to take up the inquiry; and I am sure the interests of commerce would be well furthered, if our members were to offer a prize for the best essay on the *history of the cultivation and collection of the raw material of gutta percha*, and other congenital gums bearing the same name, together with a report on the sorts offered for sale in the European markets, and the probable future of the supply.

It may be interesting to mention, that an addition is likely to be made to the list of malleable dielectrics, by the invention of Insulite. In it the tendency of vegetable fibre to absorb moisture, due to its tubular form, and by which the natural insulating qualities of the cellulose coatings is neutralised, is prevented by thorough dessication, which leaves a material of high power of insulation. This dried fibre is impregnated, under pressure at a high temperature, with a composition of paraffin and resin, which leaves an artificial substance, *said* to be equal in qualities to gutta percha as to flexibility and to ebonite as to hardness, alike unaffected by corrosives and atmosphere.

A subject which now deeply engages the attention of our Society was also referred to by the Congress. Some time was

given to the discussion of the respective rights of cable Companies which have cables close to or crossing one another, and which up to this time no one has thought of guaranteeing.

It was pointed out that the great ocean lines, the property of large industrial interests, and no less of great importance to society at large, have the protection of no security in proportion to their value. The jurisdiction of neighbouring countries over the ocean floor is a very moot question, and one that may well occupy the attention of the student of international law. At any moment, for instance, a troublesome question might be raised by Germany laying a cable westward down the English Channel, across all the cables connected with the south coast of England—a question not less complicated, should it occur that all these cables happened to be interrupted at one time. The subject being one of international law, the Congress quickly recommended the French Government to move other governments to form an International Commission on the subject. In the meantime, the Committee of your Society will do good work in formulating the case, particularly so far as the United Kingdom, the most interested owner of cables, is concerned.

The measurement of the electric light led to a prolonged discussion in the 3rd section of the Congress. The assembly was immediately divided into two camps by the attitude adopted by the French members; those who had heretofore used the candle, though admitting its defects, being opposed to the definite adoption of the Carcel lamp, undisguisedly urged by the French.

As a measure of the value of a gas flame, each standard had answered its purpose fairly well, but when used in a comparison with a flame so intense, and of so different a colour, as that caused by the electric arc, their inadequacy was evident; and, in spite of the pressure brought to bear in favour of the Carcel lamp, the Congress requested its president, M. Cochery, to endeavour to bring about the appointment of an International Commission, of which the task would be to examine the whole question, make the necessary experiments, and, if possible, decide on a form of standard of light suitable for testing the electric light, photometrically.

A concession to the wishes of the French was made so far,

that, while waiting the hoped-for result, it was decided that the Jury of the International Electrical Exhibition, just then about to commence its labours, was to use the Carcel lamp as the standard of light in their comparative tests of the apparatus to which they had to award prizes.

In the meantime, I would suggest that the comparative value of the standard candle and the Carcel lamp, each burning under conditions accurately defined and well known, may be fixed at 9·61, a figure obtained by myself and Mr. Rowden, after a series of tests in Paris, in 1867.

It may be some time before Europe is willing to accept one standard of light. Germany and England are wedded to an expression, namely, the "candle." The French are equally attached to their standard. Unless disturbed by the discovery of some standard of measurement of light which is unexceptionable, the old expressions now used are likely to be clung to. From being a household word, and therefore intelligible to all, the use of the word "candle" has become understood as a familiar expression. "Candle-power," like "horse-power," will be a term very difficult to eradicate. Society and the world at large does not interest itself in fundamental units.

While on this subject, it is due to the work of three able men to refer to their report to the Board of Trade, dated 25th August last. This committee on photometric standards, while finding a maximum difference of 27·7 per cent. of illuminating power in 115 supposed standard sperm candles tested by them, do not seek to discard the expression, but to standardise the candle itself. They recommend, for the determination of the illuminating power of coal gas, the use of the sperm candle shall be discontinued, and that for the future Mr. Harcourt's air gas flame shall be employed instead, as a means of affording with constancy the light of one average sperm candle. The report further recommends that, if lamp standards are also resorted to on account of their practical convenience, these other modes be standardised also, and from time to time be checked by comparison with Mr. Harcourt's air gas flame, which should alone be taken as the official standard.

Mr. Harcourt's new unit of light for photometry is described in

a paper read by him at a meeting of the British Association in August, 1877. He describes the air gas as a mixture of 576 volumes of air with one of "pentane," measuring the liquid at 60° Fah., or, measuring both as gases, 20 of air and 7 of pentane. Pentane, alias gasoline, he calls standard petroleum; the vapour of the liquid weighs 2½ times as much as an equal quantity of air.

The standard gas is made by allowing a measured volume of the liquid to diffuse into and mix with a measured volume of air, under an atmospheric pressure of 30 inches of mercury, and at a temperature of 60° Fah., and under the conditions; first, that when 3 cubic feet of air and 9 cubic inches of the standard petroleum (sp. gr. ·628 to ·631) are used, the result will give from 4·01 to 4·09 cubic feet of gas; second, that its rate of burning from a ¼-inch orifice, to produce a 2½-inch flame, must be between ·48 and ·52 of a cubic foot per hour. I have so far indulged in detail to show that, in this proposal, we appear to have as practical an approach to a fundamental unit as can be expected, for the measurement of light by candle-power.

But shall we be long satisfied with a hydro-carbon type of standard for the measurement of the electric light? We have used hydro-carbons as the illuminants of our darker hours, and the *candle* has been a homely and intelligible expression of comparison between these. But how long will this last? how long will it be before our way is lighted by the wonderful light that is now absorbing our interest? It will be for the International Commission, I believe, now to seek our standard for comparison from those rays that we try and reproduce when the sun, their true source, has disappeared. Professor Helmholtz and Mr. Schwendler's proposals are both full of interest, and I trust that this session will not end without having the subject well discussed by our Society.

The great feature of the year 1881 in the history of this Society, was the addition to the title, under which the words "and of Electricians" were appended to the old one.

Our fresh baptism was a necessity, and the new name was the result of a great deal of deliberation at your Council. It is possible that another name might have been preferable, and might have better expressed the enlarged sphere of our association, but for a

time the question is settled, and it would be unwise for a moment to raise it afresh.

For reasons of old association, it was considered that the word Telegraph Engineer should be stuck to: it was under that name we had grown to adolescence; and although the actual telegraph engineers were in the minority, they were strong. It may be doubted if the word "Electricians" has covered much ground. In this country there are very few people who call themselves by that title; on the Continent it is in more common use; and in America it is applied to those whom we call Engineers.

It must not be supposed that I cavil at the present selection, I understand that a large majority were for the retention of the old name; but I still feel that the title "Electrical Engineer" is daily becoming one of wide and well-understood meaning, and that some day it will find a place in the engineering profession.

Our future under our new name is a matter of great moment, and much depends on the use we now make of the vast increase of public interest in the application and study of electricity.

Exhibitions are useful as stimulants, as means of publicity, as the scatterers of good seed of all sorts in the minds of men. It is for us to gather the fruits and to prosper with their use, and if we neglect to do so, others will not. Our opportunities are many, and there are several ways of receiving benefit from using them.

First. Our Society may become better known and its numbers increase, so that our pecuniary position may be good enough to allow us to be more useful, and to embark in a wider field of labour.

Second. The authority of the Society may become more fully recognised, its search after truth more credited, so that men will in time hold it to be the most honest tribunal before which the worthiness of work can be judged.

Third. The membership of the Society will grow in public esteem, and will become a trustworthy and pure means of establishing the reputation of real workers.

It may be long before such ends are achieved. While gradually working on towards such a threefold goal, we have plenty of real business to pursue by the way.

First and foremost is Education. On this subject I crave to be

heard with no carping or weary mind, but, instead, with that warm enthusiasm without which progress in education has never flourished, and which is so necessary to give impetus to a movement within our own circle.

The great educational movement which is stirring up all society is of the greatest interest, and most attractive to all of us, when it deals with technical instruction of any kind. The supply afforded by the City and Guilds of London Institute is only increasing the demand. Of this, our learned editor, Professor Ayrton, will no doubt shortly favour us with an account. The increase of technical journals and magazines, and their constant enlargement, is an ample proof of the public demand for scientific information.

The numbers of the candidates at the science examinations of the Education Department, held annually all over the kingdom, have been steadily on the increase.

The subject of examination is divided under the heads *magnetism* and *electricity*. There is a first stage, or elementary, and a second stage, or an advanced course. The examiners are Professors Guthrie and Carey Foster. Between 1867 and 1877 the separate Classes under instruction in these subjects increased from 42 to 548; in the same period the number of students under instruction, the number examined, and the number successful, increased respectively from 1,145 to 13,980, from 728 to 10,432, and from 539 to 8,476. Since 1877 there has been little increase, but the payments on results to teachers of these subjects amounted in 1880 to £7,300.

The number of persons interested or employed on works dealing with electricity, due to the undertakings connected with the electric light and telephone, has more than doubled in the last three years, without counting those employed under the Postmaster-General. The interest of the public in everything connected with the application is tenfold.

I ask, then, is there want of evidence that this Society (or some other, if we neglect the chance) has but to seize on the favourable moment, and, taking the ball at the bound, lay the foundation for an electrical institution of training and examination which will be

of inestimable value to the rising generation? Who will say that our Society is still too young for the position of maternity?

It may be observed, that other societies do not attempt such work, and that it is left to the Schools and Universities, and to the various organisations for teaching and examining, to compete with one another for the palm of success in such educational work, and that scientific societies such as this only provide meeting-places for instructed men, where they can come in contact and exchange ideas. While acknowledging this, one has only to call attention to the existing class in the Society of Students to show that the foundation of what I suggest already exists.

If it be asked, Where do they study? and what means of acquiring knowledge do we give them outside our meetings and library? there is no answer. Since the class was established,—and the motive was excellent,—the existence of our students, except to collect their subscriptions, may practically be said to have been forgotten.

While recognising fully the work done at various institutions, notably the instruction given at Cowper Street, it cannot be said that any means at present exist by which a student of electrical science can at a moderate cost obtain good *practical* instruction in the subject, and in its countless applications.

Such an exhibition as that at Paris so far serves a purpose that, in the words of the Minister of Posts and of Telegraphs, it may be styled the "cradle of electricity," by, for the first time, opening the eyes and minds of the general public to the range of subjects allied with it; yet that exhibition failed to bring together one-half of what might have been shown, and, except to the initiated, it was not a means of much instruction. The same remarks are applicable to the forthcoming exhibition at the Crystal Palace. These suggestions are made to draw your attention to the reality of the magnitude of the curriculum for a complete course of education in the elements and practice of the subject.

I would ask, Has any one amongst my hearers yet drawn up a complete programme of instruction in the subject? Several have been engaged instructionally in it. Has it not grown so rapidly that few have had time to do it? I expect it would puzzle

many to lay down the prospectus of examinations, *theoretical* and *practical*, necessary to test the knowledge of a man calling himself, or rather entitled to be called, an Electrical Engineer.

I know no subject, even when dealing with less important branches, in which there are more snares to those who have a little knowledge. Yet there is none into which I have seen men rush with less humility.

In telegraph engineering, for instance, it is only those who have patiently worked with their own hands, and encountered and overcome the insidious difficulties, which nothing but familiarity enables them to meet with precision and promptitude, who can appreciate the necessity for long experience and good training.

So blind is the tyro to the realities of practice, and to the intricacies of the agent he uses, that technically educated men, thrown into the turmoil of such difficulties, will break down, and fail even to detect them. I have seen such, after a year's training, admit that the appreciation of the work they were engaged in was only just dawning on their minds; and these had already had some teaching, some examination, and some handling of apparatus, only open to very few.

Although an Educational Institution cannot give working practice such as I describe, I believe it can be made to give more than it generally does; and in such a one, as I have before my mind, I would, if possible, not only allow the *theory* and *practice* to march hand in hand, but I would allow the practice to precede the theory with some minds, and *vice versa*. The course would thus engage the interest of both kinds of minds, and confer the maximum of benefit.

Such an institution should include instruction in the lecture theatre, in the workshop, in the laboratory, and out of doors, by exhibition of historical examples, and by access to the best literature. It should have something more: it must be cherished and encouraged by the aid and countenance of such a Society as ours, which has already, with really little individual effort, grown up on a foundation of men and interests, which already includes all the elements necessary for the commencement of an educational enterprise such as I suggest.

Rocks ahead of such a venture no doubt exist. We may congratulate ourselves on being easily able to avoid the most dangerous. One has disappeared under the influences of this Society. The trades unionism of telegraphy is a thing of the past, and in no business does one encounter fewer prejudices against publicity. This, the spirit of the day, was remarkably exemplified at the Paris Exhibition. Once an object had found its way there, all reserve on the part of the inventor was cast aside, and a desire to afford information to all seemed to expand under the sunshine of surrounding objects of equal value and displaying equal genius.

The more, publicity of this sort is cultivated, the more necessary is it for societies such as ours, to uphold the sound work of the Society of Arts in its endeavour this session to carry through the patent bill proposed by Sir F. Bramwell's committee. I have myself, as a member of council of that society, carefully followed every stage of their proceedings, and would impress on the members of this Society the value of their work, and the great importance to inventors and society at large of the measure they propose.

Such a measure may help to bring to an end a great deal of the traffic in patents which at present often tends to keep from public use applications which ought fairly to be within the public domain, or, on the other hand, to deprive inventors of their just rights. The present ambiguous state of the law encourages the class from whom no disinterested action can be expected, and to whom the simplicity of such measures, and the publicity afforded by thorough instruction, is antagonistic. They trade on the ignorance of the public as regards inventions, and have no scruple in suppressing truth for a rise or fall on the Exchange. To them scientific discovery is an occasion for speculation: any improvement in the inventions they own is obnoxious. From them it is evident no support can be expected to a spread of public knowledge, because their profits are frequently derived from ignorance, and the less sound knowledge is extended, the more chance they have of startling the public mind into that state of temporary insanity which feeds their greed.

Our policy is so totally opposed to all sorts of *suppressio veri*, that we need have little fear that such a class will be entertained, except by accident, within our precincts. It is with pleasure one

turns to the bright example of one of our number who has made a noble use of his independence, the fruit of years of labour, and has given up freely the last results of his studies for the benefit of humanity. I speak of Professor Hughes, whose induction-balance is the greatest boon that has yet been conferred on the soldier suffering from gunshot wounds.

It is not often the case beyond the shores of our isles that men come to the front, independent of State patronage, indifferent to decorations, and either, individually, or collectively, make substantial sacrifices for the sake of promoting a good object. There are many in our ranks who are able, and I believe willing, to come forward, and render themselves immortal, by aiding in the establishment of an Educational Institution for the promotion of the knowledge of electrical engineering.

A French physicist wrote in 1829, "On n'a nul besoin de recourir à un autre agent que l'electricité, pour se rendre compte des phénomènes de toute la chimie inorganique."

We may not be far from the day when these words will be proved to be the fact, when the same agent will be known to answer for all the phenomena of change everywhere,—all integration and disintegration of matter,—alike in the make and waste of tissue in living organisms, and in the growth and decay of the vegetable world; the same agent working silently, gradually in one direction, with sudden energy in another; dormant here, stored up in active tension there; giving evidence of its presence in every direction, by motion, by heat, by light.

The word "agent" is hardly suitable to express the meaning of this *thing*, as Professor Tyndall called it years ago, when he first daily found himself dealing with its all-pervading influence.

There are not wanting those who look forward with certainty to the time when every elementary application of this *thing* will be at our service. Professor Perry, at the Society of Arts last year, promised us that every function and want of our daily life and labour would be aided, before long, by electricity. Bulwer Lytton's "Coming World," foretelling a state of society in which all life should be electricity under the control of will, may be read less as a fairy story than when it was written.

But, if in all sober earnestness, any practical approach is to be made to such a millenium, where are the men and the minds to be found who can produce such results? Surely it is amongst those who, as investigators, as discoverers, or as engineers, convert, adapt, and apply this great source of power in nature, for the use and for the convenience of man.

Mr. H. C. FORDE: Gentlemen,—I am sure that you must have all been very well pleased with the able and very interesting address of our new President, and therefore I have great pleasure in rising to propose a resolution to the following effect:—"That the best thanks of the Society are due to the President for the very interesting address just delivered by him, and that, with his permission, the same be printed and published in the Journal of the Society." We have now in the chair a gentleman who, with Col. Bolton and a few others, has been the founder of our Society. The Society was founded some ten or eleven years ago. Its family did not increase very rapidly in the first few years, but now it consists of about 1,000 members of all classes. Col. Webber has taken the chair at the commencement of the first year in which the finances of the Society have been what we may call flourishing, and where there has been some surplus in hand, with which I hope the Council will be able to deal satisfactorily. Besides the great experience that Col. Webber has had as a telegraph engineer in the Post Office Department, he is also eminent in his own profession as a Royal Engineer, and has been selected by Sir Garnet Wolseley on several occasions as a member of his staff. I had the pleasure of shaking hands with him the very day that he landed at Durban with Sir Garnet Wolseley and his staff, and he did good service there and elsewhere on active service. I therefore think that the Society ought to congratulate itself on having such an eminent man in the chair for this year of office.

I am sorry that this resolution has been put into such poor hands, as I should like to say much more in favour of Col. Webber, but the time is short, and I therefore will leave the seconder to fill up the gaps that I have left unfilled. I have great pleasure in proposing the resolution.

Mr. C. E. Spagnoletti: I have very great pleasure indeed in seconding the motion put by Mr. Forde. Lieut.-Col. Webber has given us to-night a very excellent inaugural address, and all who have heard it must feel that it is one that must have demanded considerable skill and careful attention in its compilation. He has brought before us several topics which members would do well to consider, with the view of taking them as subjects for papers to be brought before the Institution during the coming year. I was particularly pleased to hear him mention the subject of medical electricity, because, though not a medical man, I have given that subject much consideration and attention, and I think that a great deal may be done to further that branch of the science. The Germans have done a great deal more in that direction than we have, and a very excellent work has been written by Dr. Althaus on the subject. It is not a new subject. It dates back very many years, and I believe it is on record that a gentleman, years ago, living on the shores of the Mediterranean, who was taking baths for the cure of gout and rheumatism, happened to tread upon a fish called the torpedo, which may be regarded as a natural electrical accumulator, and not being pleased with the treatment it received, gave the gentleman a very severe shock which almost overpowered him; but when he recovered from the shock he found that he had been cured of his gout and rheumatism. This was one of the early applications, and appears to have been successful.

I have great pleasure in seconding the proposed vote of thanks to Lieut.-Col. Webber for his address, and also that it may be printed for the benefit of those who have not the opportunity of being present to-night, and for foreign members.

The vote was then put and carried most cordially.

The President: As it is late, I will only express my warm thanks for the very cordial way in which you have received the announcement of the act of placing me in this position, and also for the attention you have given to the words I have compiled and read to you this evening.

A ballot for new members then took place, and the following were elected:—

As Member:

Frederick Guthrie, Ph.D., F.R.S.

As Associates:

Commander L. A. Beaumont, R.N.
J. R. Davies.
John Stevenson Holt.
Charles Ferdinand de Kierzkowski-Steuart, M. Inst. C.E.
William Lachlan.
James Livingstone.
William Payton.
Henry Humphrey Rathborne.
John Henry Stephens Thomson.
David Urquhart.
Cromwell Oliver Varley.

The One Hundred and Seventh Ordinary General Meeting was held on Thursday evening, February 9th, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the previous meeting were read and confirmed, and the names of the new candidates announced and ordered to be suspended.

The following Associate was transferred to the class of Members:—

JOHN MEHRTENS.

The SECRETARY announced the reception of various books from Messrs. Macmillan, Messrs. De la Rue, Professor Hughes, F.R.S., from Kew Observatory, the Italian Government, the Lightning Rod Conference, Mr. A. A. Common, the Iron and Steel Institute, Mr. David Brooks, the Patent Library of the United States, Mr. M. F. Evrard, and from the Royal Institution, the details of which were given in the list laid on the table.

The PRESIDENT: I have now the pleasure to announce that Mr. John Aylmer, our Honorary Secretary in France (whom we are happy to see amongst us to-night), has been so kind as to present the Society with a portfolio full of the most interesting photographs taken at the Paris Electrical Exhibition. The portfolio is on the table, and will remain for inspection at the close of the meeting. It is not necessary, I think, to go through the form of proposing and seconding a vote of thanks to Mr. Aylmer, because I am quite sure that all Members and Associates of the Society will respond to the call when I ask them to join me in offering our hearty thanks to Mr. Aylmer for his kind and handsome present.

The following paper was then read by the SECRETARY, on

THE "PILSEN" ELECTRIC LIGHT ARC LAMP.

By HENRY F. JOEL, C.E., A.S.T.E.

The "Pilsen" Electric Light Arc Lamp is the invention of two Austrian engineers, Messrs. Ludwig Piette and Franz Krizik, and

is so called owing to the difficulty of correctly pronouncing the names of the inventors, Pilsen being the name of the town where the lamp was invented.

FIG. 1. FIG. 2. FIG. 3. FIG. 4.

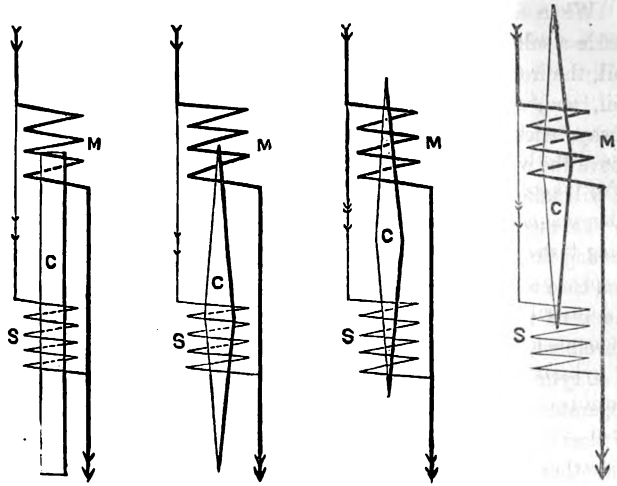
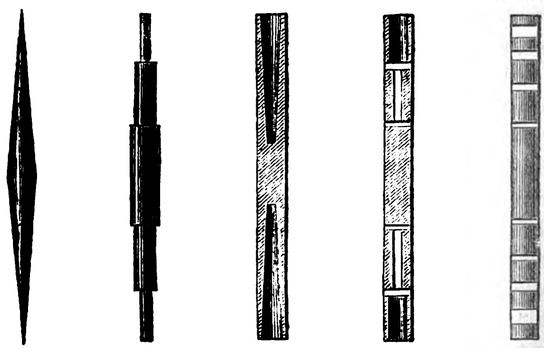


FIG. 5. FIG. 6. FIG. 7. FIG. 8. FIG. 9.



The "Pilsen" Arc Lamp.

The special and novel feature of this lamp is the use and action of a biconical or spindle-shaped iron core when suspended between, and partly through, the interiors of two magnetic

solenoids, placed one above the other, through which an electrical current is passing. When so used, such a core has no positive or balanced position, and can be moved, and will remain in any new position.

When a cylindrical iron core of the ordinary form is placed inside a solenoid coil, and an electrical current is sent through that coil, the iron core takes up a positive and balanced position in the coil, and, as is well known, when moved out of that position always tries to regain it. With two coils, M and S, placed one above the other (see Fig. 1 of the diagrams), the cylindrical core, C, will take up a position between the two, exactly in proportion to the magnetic power of each; any alteration of the current passing through either coil will disturb the balance, and cause the iron core to move up or down, and upon the balance being restored the core will return to its former position. The limit of such movement, however, is, in practice, soon reached; whilst the use of a cylindrical core necessitates clockwork gearing and releasing apparatus of a complicated nature, as instanced in the application of that system in Messrs. Siemens' differential electric light lamp, and others of that type.

In the "Pilsen" Lamp, on the other hand, the double-coned iron core, within the limit of half its length, is not so affected by moving, and has no such balanced position; and thus it has a very long extent of movement, which is utilised directly to feed the carbons in an electric light lamp, and so avoids the use of complicated mechanism.

Fig. 2 shows the double-coned iron core, C, in a similar position, between the two coils, M and S, to that of the cylindrical core in Fig. 1. Fig. 3 shows the core half-way between the two coils. Fig. 4 shows the core in the reverse position to Fig. 2. In each and all of these positions, and in any intermediate position, the action upon the coned iron core is the same, and it has no tendency to move up or down.

Figs. 5, 6, 7, 8, and 9 show different forms of core, all or any of which have the same peculiar property as the double-coned core, all being made with the greatest mass of metal in the

middle, and gradually tapering or decreasing to almost nothing at their ends, the biconical core, however, being the best of all.

The action of the "Pilsen" Lamp with the coned core is the same when placed in a horizontal, or any position.

The uniform action of this peculiar-shaped iron core is due to the equal and opposite magnetic effect which appears as the result from the decrease of the mass of iron in one solenoid being compensated for by the increase of its magnetic action, and *vice versa*, and it is this most interesting feature which constitutes the principal novelty in the "Pilsen" Lamp.

Fig. 10 of the diagrams shows a simple application of the biconical iron core and double coils. The top coil, M, is in the main circuit, the positive wire after passing round this coil being connected to the contact guide roller, *r*, and from thence through the frame and tube to the top electrode, and so through the arc to the negative wire which is directly attached to the bottom carbon. One end of the shunt coil, M^1, of fine wire and high resistance, is connected to the wire of M at the terminal at top, the other end of the shunt coil being connected to the bottom carbon-holder; the iron core is fixed inside a brass tube, which again slides inside another brass tube, round which the coils, M and M^1, are wound, the iron core being counterbalanced by the weight, W, suspended from a cord passing over the roller, R, so that the core is free to move up or down to any position. The two coils, M and M^1, are so regulated that, when the arc formed at the carbons is of exactly the proper length, usually two millimetres, the action of the coils upon the core is exactly balanced. Any alteration in the resistance of the circuits by increase of the length of the voltaic arc disturbs this balance, and the iron core with the top carbon attached descends and again restores the balance, and remakes the size of the arc to the predetermined length.

This lamp is essentially an electrical lamp, as contrasted with mechanically regulated lamps, and as made is extremely simple.

The theoretical examination of this combination of biconical core and two solenoid coils confirms its practical action. The following examination and formulæ are taken from the periodical,

Fig. 10.

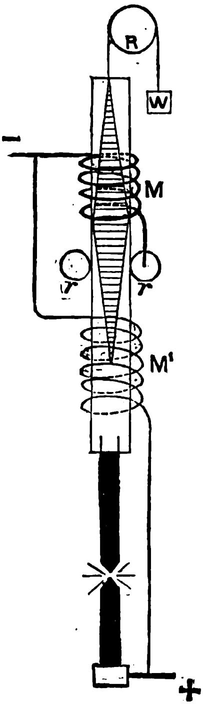


Fig. 11.

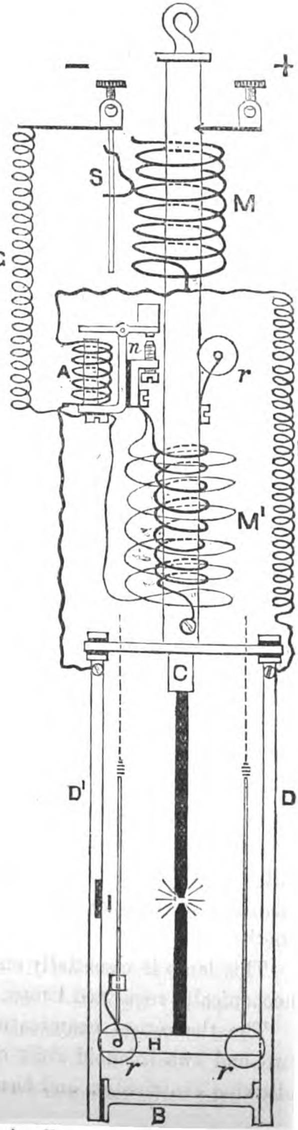
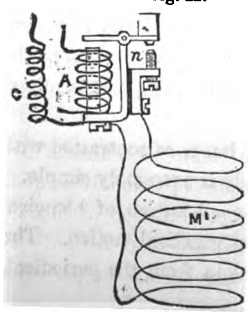


Fig. 12.



The "Pilsen" Arc Lamp.

Zeitschrift für Angewandte Elektricitätslehre, No. 12, 1881 (see Fig. 10):—

Let S represent the pull of the main coil, M,
and S^1 that of the shunt coil, M^1.
R the force pulling the carbons together, allowing for the resistance of friction caused by the movement.

The weight of the core being counterbalanced as before mentioned, the inertia of movement is the same in any position.

Let J represent the current passing in the main circuit,
and J^1 the current passing through the coil M.
J^2 the current passing through the coil M^1,
and o — the resistance of M.
a — the resistance of M^1,
y — the resistance of the carbons, and
x — that of the light.

It is to be calculated what function x is of the other variables.

The following formulæ have been determined:—

$$S = A\ J_1 \quad \dots \quad \dots \quad \dots \quad 1.$$
$$\text{and } S^1 = B\ J_2 \quad \dots \quad \dots \quad \dots \quad 2.$$

A and B being constants of the functions of the magnetic movements of the coils.

Further,
$$J = J^1 + J^2 \quad \dots \quad \dots \quad \dots \quad 3.$$
$$\frac{J^1}{J^2} = \frac{a}{x + y} \quad \dots \quad \dots \quad \dots \quad 4.$$

from 3 and 4 follow

$$J^1 = \frac{J}{1 + \frac{x + y}{a}} \quad \dots \quad \dots \quad 5.$$

$$J^2 = \frac{J}{1 + \frac{a}{x + y}} \quad \dots \quad \dots \quad 6.$$

$$S - S^1 + R = o \ \dots \quad \dots \quad \dots \quad 7.$$

If we substitute the values found as above for S, S^1 and J, J^2 in the examples 1, 2, 5, 6, into and for 7, the result would be

$$A \frac{J}{1 + \frac{x + y}{a}} - B \frac{J}{1 + \frac{a}{x + y}} + R = o.$$

From this

$$\frac{A}{1+\frac{x+y}{a}} - B\frac{J}{1+\frac{a}{x+y}} + \frac{R}{J} = o.$$

After that,

$$\frac{A\left(1+\frac{a}{x+y}\right) - B\left(1+\frac{x+y}{a}\right) + \frac{R}{J}\left(1+\frac{x+y}{a}\right)\left(1+\frac{a}{x+y}\right)}{\left(1+\frac{x+y}{a}\right)\left(1+\frac{a}{a+y}\right)} = o.$$

Further,

$$\left(\frac{x+y+a}{x+y}\right)\left[A - \frac{B}{a}(x+y) + \frac{R}{aJ}(a+x+y)\right] = o$$

If we put

$$\left(\frac{x+y+a}{a+y}\right) = o$$

then $$x = -y - a.$$

This result is of no value, being negative, for x can have a positive value only. We therefore put

$$A - \frac{B}{a}(x+y) + \frac{R}{aJ}(a+x+y) = o$$

then $$(x+y)\left(-\frac{R}{aJ} + \frac{B}{a}\right) + A + \frac{R}{J} = o$$

then $$x + y = \frac{\frac{R}{J} + A}{-\frac{R}{aJ} + \frac{B}{a}}$$

and $$x = a\frac{AJ+R}{BJ-R} \quad \ldots \quad \ldots \quad \ldots \quad 8.$$

The right side of example 8 contains the two variable elements J and y, and the resistance x of the arc in that case depends upon the current flowing. If we put $y=o$, viz., when the carbons are all burned, then x will be increased in value by the elimination of the resistance of y, and most probably the length of the arc would be increased a little. The correction for this is made by altering the true cone of the core a little only, so that, in fact, examples 1 and 2 are not quite correct. The powers of S, S^1 are also by this alteration made partly depending upon the position of the core.

We can therefore describe example 8 as

$$x = a \frac{A\ J + R}{B\ J - R} \quad \ldots \quad \ldots \quad \ldots \quad 8a.$$

We have still to eliminate the variable element J from the right side. We know from practical test of the friction of the wheel R that this variable element can only possess small value when the lamp is otherwise well constructed and worked: from this is to be seen that the alteration of the current passing, and the friction, cannot have much effect upon the arc, still we can eliminate it altogether by making R equal to nought, that is, by making W equal to the weight of the iron core minus the friction-resisting motion. After that equation 8a becomes

$$x = \frac{a\ A}{B} \quad \ldots \quad \ldots \quad \ldots \quad 8b.$$

x is therefore nearly absolutely constant.

The weights of the carbons during each stage of their burning is the same, through their shortening proportionally, and the attendant changing of resistance being compensated by the alteration of the iron core, which is very carefully attended to (we call special attention to this so as to avoid any mistake), the length of arc of such a lamp would therefore be constant. The arc length of a lamp of which x possesses a constant value is a function of the strength of the current: the length of the arc is of course altered by different carbons, we therefore either compensate their varying resistances or use one description only.

The example 8b can in practice be very well used: $\frac{x_2}{a}$ represents, for instance, the loss of current through the shunt circuit; $\frac{x_2}{a}$ therefore must be as small as possible. A good proportion is 0·04, now the resistance of the light.

With good strong light, each		= 0·5 to 1·0	S.U.
,,	medium ...	= 1·0 to 2·0	,,
,,	less	= 2·0 to 3·0	,,
,,	dividing ...	= 3·0 to 5·0	,,

As an example, let it be $\frac{x_2}{a}$ = 0·04 and x_2 4 S.U., a therefore = 100 S.U.

Further, we can as nearly as possible, for practical purposes, say $\frac{A}{B} = \frac{m}{n}$ if m and n represent the number of turns on the wire spools.

If a is rightly given above in the proper length, so is accordingly known the size or substance of the wire which has to be used. We can therefore take m to be the same, and with that all dimensions needed for the construction of the lamp are known, and a lamp of constant resistance can be made, a most important result for burning a number in one circuit.

Fig. 11 is a diagram of the electrical construction and connections of the "Pilsen" Lamp as actually used. Fig. 12 is a diagram of the automatic cut-out electro-magnet.

The negative wire of the main circuit is connected to the terminal on top at the left, from thence it passes across to the main coil, M, by means of the sliding contact spring, S; after it has passed round the coilings of M, it splits into two circuits, one wire passes round the small electro-magnet, A, and is then connected to the rod, D^1 (insulated from the frame of the lamp), and so down to the contact roller, r, and lower carbon and holder, H. The other of the two split wires passes down through a resistance coil of iron wire, E, and is attached to the other rod, D (also insulated from the frame), and then to the lower carbon-holder by the contact roller, r. The positive wire enters at the right-hand top terminal, and makes direct contact with the frame and top carbon, thus completing the main circuit through the carbons and arc.

The shunt circuit is connected at the negative terminal, and passes through a comparatively thick German silver resistance coil, G, and then makes contact with the iron frame of the electro-magnet, A; from thence the wire is connected to a fine German silver wire coil of about 130 ohms resistance, wound on the outside of the shunt coil, M^1, the other end of this coil being connected tc the contact screw, n, and to one end of a comparatively thick copper wire of low resistance which is coiled inside the German silver wire on M^1; the other end of this inside copper wire coil is attached to the metal frame of the lamp, and so completes the shunt circuit, the object of the supplementary resistance, G, being to make up a

total resistance with the copper coils inside M^1 about equal to the lamp when burning, and to avoid heating when the main current all passes through that shunt or partial shunt circuit.

There are some interesting and novel electrical details in this lamp. The arrangement for altering the length and number of convolutions of the wire on the main coil, M, is, I believe, new, and is effected as follows, viz.:—After the wire is all coiled on M (see Fig. 11 and Fig. 13), the insulation is scraped off a strip ½ in. wide all down the outside of the coil, leaving a ridge of bare copper wire; the connection is made through the contact spring, S, sliding up and down the fixed rod, and pressing against the exposed wire, the bottom end of the rod being insulated; by moving S up or down, the length of the coil, M, may be increased or diminished at will, and consequently the pull of the coil M. This affords a ready method of adjusting the length of the arc, and also regulating the balance should the carbons vary in the resistance. The resistance of the main coil, M, is ·025 of an ohm, and the difference of resistance afforded by the sliding contact, S, when at extreme ends, is from ·023 to ·025 of an ohm.

The use of the small electro-magnet, A (see Figs. 11, 12, and 13), for automatically short-circuiting the high resistance shunt coil on M^1, when the carbons are all consumed, or when there are no carbons in at all, is also interesting. As before described, a split wire from M passes through this electro-magnet. The iron frame of A is made of a bell-crank shape, so that the armature at the top is a prolongation of the bottom pole, thus utilising both poles. This armature is pivoted in the centre, and on its outer end is weighted to overbalance and make contact with the adjustable contact screw, *n*, fixed to an insulated bracket at side of the frame of A. One end of the fine wire shunt coil on the outside of M^1 is connected to the wire of G, and to the metal frame of A at bottom, and the other end to the copper shunt coil and insulated bracket and contact screw. When the lamp is not burning, the armature of A makes contact with the screw, *n*, and short-circuits the fine wire coil on M^1, the main current then passes through the thick supplementary resistance wire, G, and the inside copper coil of M^1. When the lamp is burning, the main current passes through A,

and attracts the armature, and retains it, thus breaking the contact at *n*, and adding the fine wire coil of M^1 to the shunt circuit, which then balances the lamp.

When the carbons are all consumed, the electro-magnet, A, automatically cuts out and breaks the arc: this is done by inserting a small piece of an insulating material in the guide rod, D^1, at I. When the bottom carbon-holder, H, rises to the insulated insertion, I, the roller, *r*, on that side becomes insulated from the rod, D^1, and the electro-magnet, A, is cut out of the circuit, the armature is released, and the weighted side remakes contact, and short-circuits the German silver coil on M^1. The top coil then proponderates and pulls the top carbon up, and so completely separates the carbons, and breaks the arc; the current then passing through the thick shunt coil and wire, G. During this latter operation the supplementary wire and split circuit, E, keeps the circuit through the arc (which would otherwise be broken by the insulation at I), and thus allows the main coil, M, to separate the carbons, and prevent the burning of the metal holders, H and *h* (see Figs. 13, 14, and 15).

The mechanical construction of the "Pilsen" Lamp is also very good. The frame of the lamp (see Figs. 13, 14, and 15) consists of a brass tube, mounted between two brass plates, with two iron rods, D^1 and D, joined across at the bottom by the stretching piece, B; the iron core, C (see Fig. 14), is fixed inside a brass tube, which again fits loosely in the tube of the frame, and is guided by contact rollers, *r* and *r*, so that it moves with very slight friction; the weight of the iron core, C, is counterbalanced by the bottom carbon-holder, H, and weight, W, the connection being made by means of the cords and rods, and the pulleys, R and R^1; the metal rods, DD (Fig. 14), being used in the vicinity of the arc. The carbons are fixed as shown, one to the core tube, C, and the other to the holder, H.

One of the pulleys, R^1 (see Fig. 14), has very fine teeth cut in its outer rim, and a weighted pawl, or click, P, rests upon and gears into the teeth; the object of this being to restrain the cord which must in one direction rub over the pulley R^1, and thus serve to arrest the parting of the carbon when there are any fluctuations in the current.

Fig. 13.

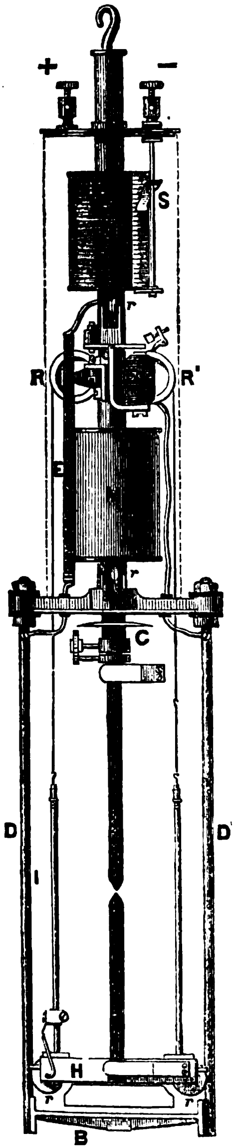


Fig. 14.

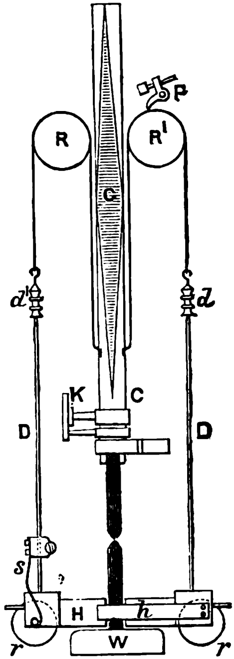
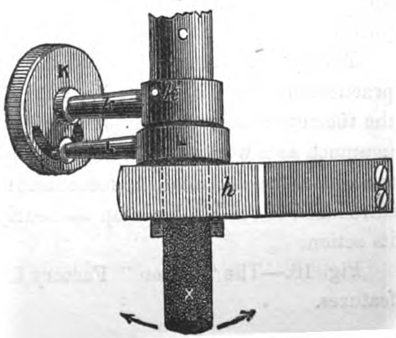


Fig. 15.



The " Pilsen " Arc Lamp.

The carbons are fitted and adjusted in a simple manner: they are inserted into the spring clips, *hh*. The bottom carbon and holder can be partly adjusted by altering the lengths of the two side cords: this is done by screwing or unscrewing the nuts, *d* d^1, attaching the cords to the rods. The top carbon can be adjusted to any position by the holder shown at Fig. 15. The spring clip, *h*, is attached to the collar and arm, L, and the two are pivoted at K, and are free to move laterally; above L is a fixed collar and arm, *k*, and on the end of that arm a milled head, K, is free to burn. K has an eccentric slot cut in its face, into which a pin projecting from the end of L is inserted. By turning the milled head, K, the arm, L, and carbon clip, *h*, are moved backwards or forwards, as may be required. The core tube, C, can also be moved round.

The lower carbon-holder, H, runs by means of the contact rollers, *r* and *r*, between the guide rods, D^1 and D, the contact being maintained by the spring, *s* (Fig. 14). Sometimes a permanent electrical connection is made by a loop of wire attached to the rods, D, and holder, H.

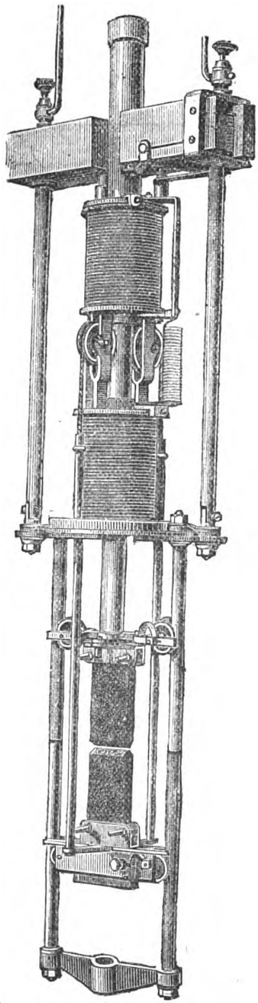
If a fixed focus lamp is required, the pulleys, R and R^1, are made double, one being twice the diameter of the other; the cord that passes over the larger pulley being connected to the top electrode, whilst the bottom electrode is connected to the cord passing over the smaller pulley, the different sized pulleys allowing the carbons to feed together exactly in proportion as they are consumed.

The top of the lamp with the coils is completely encased in a zinc cover box. The globe is put on from below in the hanging lamps (see Fig. 16), and is supported on the ash pan which slides up and down the rod at the bottom. This is very convenient for putting in fresh carbons, etc.

The apparent complication of the "Pilsen" Lamp, as made for practical use (see Figs. 11, 12, 13, 14, and 15), in contrast with the theoretical construction (see Fig. 10), is really a simplification, inasmuch as a workman has no adjustment to make, and no screws to unloose, the electrical and mechanical refinements being specially introduced to render the lamp as nearly as possible automatic in its action.

Fig. 16.—The "Pilsen" Factory Lamp which has some novel features.

FIG. 16.



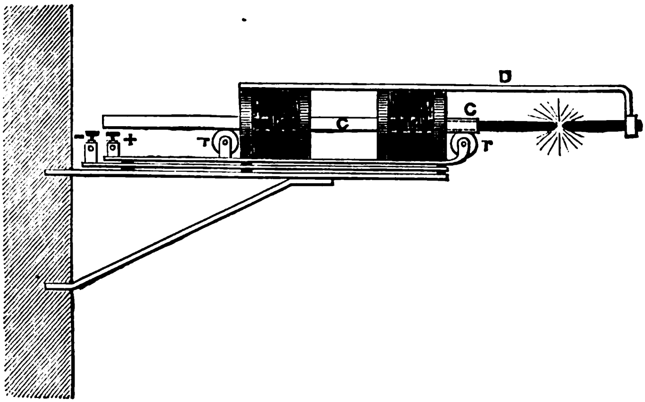
The "Pilsen" Arc Lamp, Factory Type.

This lamp is made to burn 100 hours if necessary. The electrical connections are the same as those in the lamp shown and

described (Figs. 10 to 15). The small control electro-magnet in this lamp is fitted in the top wooden frame at the right side, and is there out of the way of harm. The mechanical construction of this lamp much stronger than the hanging lamp (Figs. 10 to 15): there are two sets of contact rollers, one set attached to the top and one set to the bottom carbon. The principal novelty in this lamp is the use of plate carbons.

Some of these lamps have been in use in Mr. Piette's paper factory at Pilsen, and work remarkably well: they have proved

FIG. 17.



The "Pilsen" Arc Horizontal Lamp.

very suitable for factory purposes, where a cheap and reliable light is required.

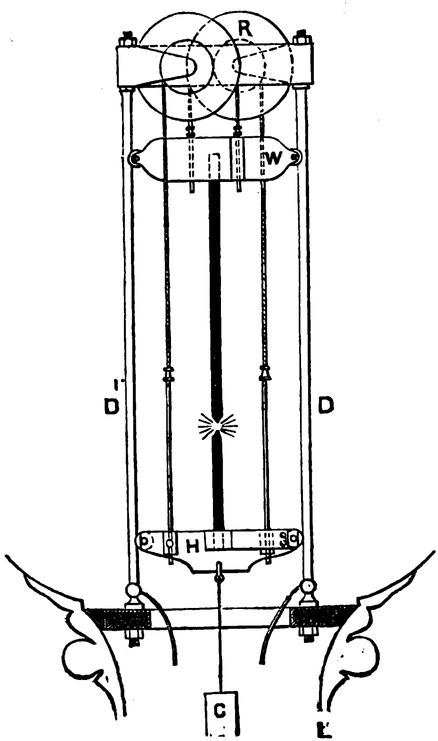
Fig. 17 shows a diagrammatic drawing of the "Pilsen" Horizontal Lamp. The iron core, C, is fixed inside a brass tube, and is supported and free to move upon the contact rollers, *rr*; one carbon is fixed to the end of the tube, C, and the other to the pivoted arm, D; the coils, M and M', are practically arranged in the same way as in the previously described lamp.

The special advantage of this form of lamp is that it can be used in low-roofed factories, close up to the ceiling. This lamp was shown constantly at work in the Electrical Exhibition at Paris, and burned remarkably steadily.

Fig. 18 shows the "Pilsen" Lamp adapted for street lighting.

In this lamp the counterbalance of the iron core is reversed, and the coils placed at the bottom, and inside the tube of the top of the lamp; the side rods, D D[1], weight, W, holder, H, and rollers, R, with their cords, are, except for being reversed, the same as the hanging lamp described in reference to Figs. 10 to 15.

Fig. 18.



The "Pilsen" Arc Lamp, Street Type.

This special arrangement of the lamp allows the coils to be placed in safety, and avoids shadows on the globes.

The advantages claimed for the "Pilsen" Lamp are:

Its extreme simplicity.

Its almost perfect working.

A steady and white light, of good power.

The ease with which the carbons can be fitted.

It has a constant electrical resistance, enabling any number of lamps to be used in one circuit.

It has a continuous feeding movement.

Also automatic appliances provide for all practical contingencies; and a special and distinct advantage is, that it can be worked with almost any description of engine: the absence of all clutches and releasing gear enables the lamp to quickly adjust itself to variations of speed.

The "Pilsen" Lamp has been fitted in many places and with unqualified success, and is at present being exhibited in the Crystal Palace, six hanging lamps illuminating the Handel Orchestra; it can also be seen practically at work at Messrs. Wells & Co., Shoreditch, as well as in different parts of the country. On the Continent the lamps have a very large sale, and give great satisfaction.

The six hanging lamps shown are all worked in one circuit from a Schukert dynamo machine, revolving at 850 revolutions per minute, and driven by a Ruston and Proctor single cylinder portable steam-engine, with the ordinary governors. The current passing through the lamps is about 9 Amperés, the electro-motive force of the current being about 400 volts, the total resistance being about 45 ohms.

The candle-power of the "Pilsen" Lamp, such as exhibited, is what is popularly known as 2,000 candles: as this, however, is a matter upon which no two electrical engineers can agree, the author has not given any of the many tests made. The members of the Society may judge for themselves by comparing the light of one lamp alone (the other five being cut out) with the gas that ordinarily lights the meeting hall.

Mr. H. F. Joel: I would just make a few remarks supplementing the paper, to the effect that, as the carbons in the lamps burn down, their resistance becomes less. Such a change of resistance upsets the balance between the two coils, but the evil is

obviated by prolonging the ends. This overcomes the difficulty, and makes the movement of the coil practically constant. The theoretical considerations and calculations are useful, inasmuch that from them any lamp of this description can be constructed. The resistances of different sized lights and the proportions to observe between the two coils are given in the paper.

To show the quantity of light given by one Pilsen arc lamp, I will switch off five of those now burning, that one only may remain. [Experiment made.] As usual with exhibitions of this kind, our arrangements were made hurriedly, and consequently somewhat imperfectly, and the result is, I am sorry to see, that the exhibition is not as good as it should be. No doubt many present saw the Pilsen lamps burning at Paris, and will be able to vouch for their good quality. Some disturbance is now caused by an overlooked insertion in the circuit of one lamp, which is only intended to burn by itself with the current supplied by one machine.

I will now show you that if a lamp goes out it does not cause any disturbance to the other lamps in circuit. [A lamp over the President's table was lowered, and, after removing the glass globe, the speaker blew out the arc flame and held the carbons apart, and the other four lights remained as they were.] The pull of the two carbons to close together again (some pounds) exemplifies the strong action of the coils to restore the balance. If I release the carbons [does so] they immediately rush toward each other, but do not touch: they exactly remake the arc of its proper length, a most interesting and novel feature in this lamp. I am not aware of any other description of lamp which could be subject to such treatment without becoming deranged.

The PRESIDENT: I am sure that there are many gentlemen in the room who wish, not only to ask questions, but to offer remarks. There is one thing that Mr. Joel has omitted in his paper: I had hoped that he would have also given us a description of the lamp known as the "Joel," which is an arc incandescent lamp, but we see that he has confined himself to the invention of MM. Piette and Krizik. He has also omitted to mention the proportion of gramme degrees of heat represented per candle-power per second which is needed as a means of comparison with other arc lamps. Before

asking for the usual vote of thanks to Mr. Joel, I will invite any gentleman who may wish to favour us with his remarks to do so.

Mr. ALEXANDER SIEMENS: In the paper our differential lamp is spoken of as being complicated, in comparison with the Pilsen lamp, and the special reproach was with reference to the wheels. Of course I have not observed the action of the Pilsen lamp much, and I do not want at all to judge it by what it does to-night, because I am very well aware myself how very difficult it is to get experimental lamps to act when they are wanted to. But as regards the complication of the lamp, I should like to draw Mr. Joel's attention to the fact that he has got so many magnets and sliding contacts, that I think they quite make up for the complication of a few wheels such as we have got in our lamps. We only employ two wheels, and we find in practice the sliding contacts of an electric lamp are the most difficult part to keep in order. With lamps of eight webers, Mr. Joel may find it comparatively easy, but when he goes to larger lights, he may find that the large currents decline to leave the sliding contacts alone, and, what with carbon flying about, accidental dirt getting in, and the presence of moisture in the atmosphere in outdoor work, sliding contacts are very treacherous things, and apt to give rise to a deal of trouble.

Another thing. The lamp as it is, is long enough, though for the illumination of large rooms, with clear spaces such as this, no inconvenience may arise by their employment, as the lamps can be made ornamental; but when lamps are required to burn, say, 16 hours, and are to be similar to those before us, their length would be excessive, and additional guiding pieces to those now provided would be required, which would make the arrangement complicated, and I do not think that there would be much to choose between them and those differential lamps which have been specially named in the paper as being very complicated. At any rate it should be acknowledged that the way in which the regulation is effected in the Pilsen lamp is a very good application of the electrical law of attraction for conical iron cores.

Professor AYRTON: While the paper was being read I made a few measurements of the current and electro-motive force, using

Professor Perry's and my ammeters and voltameters for this purpose. I find that the total electro-motive force of the machine is a little under 400 volts, the current passing through all the lamps about 12 ampères and the electro-motive force of the centre lamp a little under 75 volts. Consequently there are 43,000 foot pounds per minute of work being expended in the centre lamp, or about 1·2 horse-power.

The PRESIDENT: The Council had hoped that there would have been a stronger response to the paper this evening, and that many gentlemen would have desired to make remarks or to ask questions of Mr. Joel, but such does not appear to be the case. Mr. Joel has bestowed unusual care in the preparation of his diagrams, and his paper contained a clear description of the lamp. Before proposing a vote of thanks, perhaps Mr. Joel would like to favour us with a few remarks in reply to Mr. Alexander Siemens, especially with regard to the question of maintenance.

Mr. H. F. JOEL: I must apologise for the bad performance of the lamps this evening. Personally, I have never seen lamps on this system burn so badly before. Their electrical construction is very interesting, and it was on account of that and their burning so steadily that induced me to bring this evening's paper before the Society. I would like to mention the use of the controlling electro-magnet, A, in Fig. 12. It is an automatic positive cut-out, so termed because it differs from the differential cut-outs employed in most lamps, *i.e.*, it is certain and positive in its action, and is not balanced by the difference of electrical currents passing through varying strengths of electro-magnets, as is the case in other lamps.

I think you will admit that, as a purely electrical lamp, the Pilsen shows the result of a vast amount of work and knowledge. It seems to me that every part has been worked out theoretically and practically, and the result is quite a triumph in technical knowledge.

In reply to Mr. A. Siemens' objection to the length of the carbon, I should say that the carbons in the lamps now burning will last for 12 hours. That is a fair average, and I think a practical time. In the slab carbon lamps, they will burn for 100 hours. The lamps before you are, I believe, the first in which flat

carbons have been used alternatively with round carbons. Here is a double-coned core, which you will see is fixed in a brass tube, and this constitutes the whole working gear in the inside of the lamp. In the horizontal lamp the double-cone core holds the carbon, and the brass tube containing it is placed on rollers. It is a fact that by simply turning up the negative carbon you can take the core out and place it in again whilst the current is passing, and when replaced the lamp will again work perfectly. That seems to be a very simple and practical form of lamp. As an instance of the simplicity of the system, I may mention that lately we have had some of these lamps going at the Smoke Abatement Exhibition at Kensington. They were fitted up in a short time, and left in charge of a young fellow who had never seen a lamp of the kind before, and who has attended to them for about three months with great satisfaction, notwithstanding that an engine of very inferior quality was employed, the continuous feeding of the lamp allowing such an engine to be used, and the result to be a practical success.

The PRESIDENT: Those who were present at the Paris Exhibition will remember the complete success of the Pilsen lamps which were placed on the main staircase, in the centre of the building, and also in the gallery. The steadiness of the lamps during the whole time of the Exhibition was rather remarkable.

It may be interesting to the meeting to mention another subject in connection with electric lighting, but not touching upon the paper we have had. It is that Messrs. Crossley, the makers of the Otto gas-engine, have succeeded with a half-horse-power engine and a large fly-wheel in maintaining efficiently ten incandescent lights. I think that that is probably due to the excellent quality of the mechanical work in their engines.

I now propose, and ask Mr. Willoughby Smith to second, a vote of thanks to Mr. Joel for his interesting paper this evening, particularly for the trouble he has taken (and everybody who has exhibited apparatus at a lecture knows how much that trouble is) in preparing, not only his diagrams, but his lamps and connections for our enlightenment, and in order to interest us this evening.

Mr. WILLOUGHBY SMITH: I am sure nothing I could say would

induce the gentlemen present to give a more hearty vote of thanks than they are prepared to do for the paper. I have much pleasure in seconding the proposition.

The proposition was put and heartily carried.

A ballot for new members then took place, at which the following gentlemen were elected:—

As Foreign Members:

M. V. Campos da Paz.
J. M. de Lemos Basto.
G. de la Toranne.
Joseph Willot.

As Members:

Thomas Sutton Clark.
Prof. Arthur W. Rücker, M.A.

As Associates:

George Lee Anders.
William Henry Ballard.
William John Baxter.
Reginald Belfield.
William W. Browning.
S. H. Byrne.
Lieutenant George Carr, R.E.
Samuel Thomas Dalton.
Joseph Emerson Dowson.
Reginald John Jones.
John Howard Mummery.
George John Somerville.
James Ernesto Spagnoletti.
Lieut. P. G. Von Donop, R.E.
Arthur Wright.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR 1881.

RECEIPTS.

	£ s. d.	£ s. d.
To Balance, December 31st, 1880		232 1 11
„ Subscriptions paid up for previous years ...		96 14 6
„ Subscriptions for the year 1881...		1,009 14 6
„ Subscriptions paid in advance		29 19 6
„ Entrance Fees due 1880	17 17 0	
„ Entrance Fees due 1881	136 10 0	
		154 7 0
„ Life Compositions...		175 0 0
„ Publishing Fund		4 4 0
„ Sale of Journals		117 16 7
„ Sale of Ronalds Catalogue	51 7 3	
„ Charges for delivery and binding ...	1 10 3	
		52 17 6
„ Profit on exchange in Foreign remittances ...		0 17 7
„ Dividends on Stock (Premium Fund)		3 18 2
		1,877 11 3
„ Due to Secretary on Petty Cash Account ...		0 4 5
		£1,877 15 8

EXPENDITURE.

	£ s. d.	£ s. d.	£ s. d.
By Salaries and Clerical Assistance ...		332 10 0	
„ Shorthand Reporter		21 0 0	
„ Attendance, Refreshments, and other expenses attending Evening Meetings		31 13 10	
„ Printing and Illustrating Journal and cost of Abstracts and Advertising	353 8 3		
„ General Printing and Stationery	60 8 4		
		413 11 7	
„ Insurance		5 0 0	
„ Purchase of Books and Pamphlets	14 8 3		
„ Binding Books and Periodicals	20 2 4		
		34 10 7	
„ Rent, Gas, and Firing		215 9 2	
„ Postages, Cost of forwarding Journals and Notices of Meetings, and General Office Expenses		114 7 8	
„ Petty Expenses of Local Honorary Secretaries		1 12 2	
„ Bank Charges on Foreign and Provincial Drafts, &c....		0 15 9	
			1,170 10 9
„ Extraordinary Expenditure, viz.:—			
Conversazione at University College		40 15 6	
Expenses of General Meetings in Paris		44 11 2	
Expenses in connection with the Paris Exhibition...		23 1 11	
			108 8 7
„ Balance in hands of Bankers			598 16 4
			£1,877 15 8

We have examined the above Account, with the Vouchers of the Society, and find it correct, leaving in the hands of the Bankers £598 16s. 4d.

J. WAGSTAFF BLUNDELL, }
FRED. CHAS. DANVERS, } *Auditors.*

BINDING ACCOUNT (Late Conference Reception Fund Account).

	£	s.	d.		£	s.	d.
To Balance, December 31st, 1880	21	4	1	By Balance of Account for Binding Books and Pamphlets of the Ronalds Library	30	13	4
„ Further Subscriptions received	9	9	3				
	£30	13	4		£30	13	4

We have examined the above account and find it correct.

J. WAGSTAFF BLUNDELL, } *Auditors.*
FRED. CHAS. DANVERS, }

ESTIMATE OF ASSETS AND LIABILITIES ON THE 31st DECEMBER, 1881.

ASSETS.

				£	s.	d.
Balance in hands of Bankers				598	16	4
Unpaid Subscriptions and Entrance Fees, estimated amount realisable				237	1	0
Amount due for Advertisements in the Journal ...				20	0	0
Journals in stock				637	2	1
Ronalds Catalogue, say				100	0	0
Estimated value of Furniture, viz.:—						
As per last Balance Sheet ...	162	0	0			
Less depreciation, say	16	0	0			
				146	0	0
Books (other than the Ronalds Library), Pictures and other objects presented to the Society valued at £300, but this sum is not commercially realisable.						
				£1,738	19	5

LIABILITIES.

				£	s.	d.
Subscriptions received in advance				29	19	6
*Balance of Premium Fund uninvested				6	13	1
Outstanding Accounts, viz.:—						
Balance of Account for Printing Journal	12	1	6			
Advertising Journal	3	2	0			
				15	3	6
Balance *Cr.*				1,687	3	4
				£1,738	19	5

* The Premium Fund is represented by £100, 4 per cent. Indian Government Stock.

E. GRAVES, *Honorary Treasurer.*
F. H. WEBB, *Secretary.*

ABSTRACTS.

F. HIMSTEDT—DAMPING OF MAGNETS BY IRON PLATES.

(Annalen der Physik und Chemie, B. XIV., H. 3, No. 11, 1881, pp. 483-503.)

The damping of magnets by means of masses of metal which do not possess magnetic polarity has been investigated both theoretically and experimentally. Gauss was the first to develop the equation of motion of a magnet swinging in a coil, on the assumption that the damping forces are exclusively due to the induced currents in the coil. The case is somewhat different when the damping is caused by metals which possess magnetic polarity, especially iron. It is known that iron has a greater damping effect than any other metal, and that only a part of this damping can be explained by the induced currents. As, however, the subject has never been thoroughly investigated, the author undertook a series of experiments to determine how much of the damping was due to induced currents, and to what cause the remainder was to be ascribed.

All the experiments were made with the same magnet, which was in the form of a rectangular parallelopiped, 100 mm. long, 10 mm. high, and 10 mm. wide. The magnetic moment of the bar was determined three times during the experiments, and was found to have the values—

14th Dec., 1880.	23rd Feb., 1881.	11th July, 1881.
7,240,300	7,239,500	7,240,000

The magnet was supported by a bifilar suspension, clamped at the lower end, and passing over pulleys at the upper end, by means of which the distance between the two threads could be varied from 8 mm. to 64 mm. Attached at right angles to the magnetic axis of the bar was a brass rod about 200 mm. long, on which were movable weights to permit of alterations in the moment of inertia. The deflections were read by means of a telescope and scale. The bodies used to produce the damping were plates and strips of iron, which varied from 0·13 to 6·4 mm. in thickness, this being determined from their weight and specific gravity. Before experimenting, all the plates were packed in loam and raised to a white heat, and allowed to cool very gradually. In spite of this, however, pieces cut from the same plates sometimes showed different effects. The distance between the plate and the magnet was regulated by placing the former on a small table provided with three levelling screws.

The chief difference, as found by experiment, between damping by copper plates and by iron plates is this: with copper, the logarithmic decrement is inversely proportional to the time of oscillation; with iron, the logarithmic decrement is independent of the time of oscillation. The alterations in the times of oscillation were produced by altering the moment of inertia, the directive force of the suspension remaining the same. A series of observations

was made with the magnet at different distances from the damping plates, and it was found that there was a slight alteration in the value of the logarithmic decrement when the time of oscillation was altered, in some cases amounting to as much as 7 per cent. This departure from the law stated is not to be attributed to any errors of observation, but to the fact that the time of oscillation of the magnet is more or less altered by the iron plate placed underneath it, and in such a way that the calculated alterations in the directive force acting on the magnet differ as much as 2 per cent. of their total value for different times of oscillation.

A part of the damping action no doubt depends on the induced currents in the iron plate, and must be a function of the time of oscillation, and it is of interest to investigate the ratio of this portion to the whole force. On the assumption that an iron sphere has magnetic polarity, but not coercive force, Herr Hertz has found that the damping effect of an iron ball must be

$$\frac{\sqrt{1 + 4\pi\theta}}{\sigma}$$

greater than that of an equally large copper ball, where $\theta = 30$ (the constant of magnetic polarisation), $\sigma = 6 \left(\frac{\text{conductivity of copper}}{\text{conductivity of iron}}\right)$, which values substituted in the formula give a result $= 3$. Assuming that the above holds also good for plates as well as balls, it was found by experiment that with a plate 1·6 mm. thick, at a distance of 11·5 mm. from the magnet, not quite $\frac{1}{3}$ per cent. of the total effect was due to induced currents. With plates 6·4 mm. thick, at a distance of 11·5 mm., rather more than $\frac{1}{2}$ per cent., and at 1·5 mm. distance, not quite $1\frac{3}{4}$ per cent., was due to these currents. These results show that the part of the damping effect which is a function of the time of oscillation of the magnet is only an extremely small fraction of the total damping.

The remaining part has been explained on the assumption that unlike poles are induced in the iron plates under the poles of the magnet, and that these poles still retain their effect after the magnet has advanced further in its path. The author admits that this would account for the increased damping effect of iron as compared with copper, but he raises two objections:—Firstly, the fact that the logarithmic decrement of a damping caused by iron is independent of the time of oscillation of the magnet, from which it is evident that the work of the damping force must be independent of the velocity of the swinging magnet. Secondly, he concludes from his experiments that the forces which cause the greatest damping are equally independent of the time, and that therefore, for the most part, the damping caused by the iron plate must be explained in other ways.

The author concludes that a large fraction, at least 0·84, but probably more, of the whole damping force is due to the coercive force of the iron, and he quotes an observation of Herr Warburg which tends to explain this conclusion. "An iron wire has had a certain permanent moment m_0 given to it by a longitudinal magnetising force k_1. Now let magnetising forces act on the wire, which continuously increase from o to k_1, and then continuously decrease from k_1 to o, it will then be found that for the same magnetising force k_1 the magnetic

moment is greater if k is taken during the decrease than if it is taken during the increase. After several repetitions of this operation, the wire will be found to be in a stationary condition, in which for $k=o$ the same moment m_0 is always obtained, and for $k = k_1$ the same moment $m_0 + m_1$."

Perhaps, therefore, it may be concluded from the results of the statical experiments, together with the law that the logarithmic decrement is independent of the time of oscillation, that all the damping effects of an iron plate, with the exception of those due to induced currents, are produced by the coercive force of the iron. At any rate it can certainly be said that by far the greater part of the damping effect can be explained by the above observation of Herr Warburg, but not, as has hitherto been done, by the action of forces which are in any way dependent on the time of oscillation.

The author adds two further observations to his paper:—1. If a bar of iron is placed at right angles under a magnet with their centres in a vertical line, the time of oscillation is more or less diminished, and most when the width is small compared with the length. If an iron bar is placed with its centre under either pole of the magnet, the length of the bar being less than that of the magnet, the time of oscillation increases with the width of the bar up to a certain point and then diminishes. 2. Of two copper plates of otherwise equal dimensions, the thicker has a greater damping power than the thinner; for the iron plates experimented on, the converse holds good.

R. COLLEY—THE EXISTENCE OF A DIELECTRIC POLARISATION IN ELECTROLYTES.

(*Annalen der Physik und Chemie*, *B. XV.*, *H.* 1, *No.* 1, 1882, *pp.* 94-111.)

Following up the ideas held by Faraday and Clerk Maxwell, that through the action of an electro-motive force on any body which is not an absolute insulator, electric conduction as well as dielectric tension is produced, the author has undertaken a series of experiments to show that the two exist side by side. It is to be remembered that no sharp line of demarcation can be drawn between non-conductors and conductors. Thus it is barely probable that in a class of chemically homologous bodies, as, for example, in the fatty acid series, the lower members of the group, formic acid and acetic acid, should be electrolytes, and the higher members, as stearic acid, dielectrics, without the intermediate terms showing a mixed character.

Suppose a layer of liquid capable of electrolysis placed between two closely opposed metal plates. Let one plate be to earth and the other connected through a galvanometer to one pole of a battery. On closing the circuit we should expect, on theoretical grounds, the production of two kinds of charge: firstly, a galvanic polarisation, *i.e.*, a charging of each plate after the manner of a condenser; secondly, a dielectric polarisation. For the production of these charges corresponding quantities of electricity would have to pass through the galvanometer coil. In the metallic part of the circuit, besides true conduction,

an electric translation or dielectric polarisation takes place; the latter, however, is quite insignificant, owing to the slight fall of potential due to the high conductivity of the metal, and to the small sectional area of the conductor, and can therefore be neglected. If the liquid is a comparatively good conductor, the galvanic polarisation is so predominant that the dieletric polarisation disappears in comparison. To charge the electrodes large quantities of electricity are necessary, which, owing to the high conductivity, flow through the circuit in a short time. If, on the contrary, the liquid is a bad conductor, in the first place greater dielectric polarisation occurs, since this is directly proportional to the fall of potential in the liquid, and inversely proportional, under like conditions, to its conductivity; and, in the second place, the charge of the electrodes can only occur slowly, causing weak currents of long duration, which cannot conceal the almost instantaneous currents by which the dielectric polarisation is caused.

With regard to the discharge currents, the following has to be remarked. If the E.M.F. of the cell is greater than the minimum necessary for the decomposition of the electrolyte, and the circuit be closed sufficiently long, a separation of ions will occur at the electrodes. These ions can only produce an opposed current if they can accumulate on the electrodes without further decomposition, and can recombine to form the original compounds. But in the case of organic bodies, such as those considered by the author, of complicated formation, this is never the case; and therefore with these bodies the chemical depolarising current does not enter into consideration.

After investigating the subject mathematically, the author goes on to describe his method of experimenting, in which he confined himself to observations of the discharge current. The make and break arrangement consists of an iron hammer which is allowed to fall from a variable height, and in its fall the liquid condenser is joined to one pole of the battery, then the battery is disconnected; next an instantaneous discharge occurs as the falling hammer completes a certain circuit, and, finally, the remaining discharge takes place. By means of a key either the first or second of these discharges can be made to pass through the galvanometer.

The condenser was made up of three silvered pieces of plate-glass, placed on the top of each other in a tinned copper trough, and kept at a distance of 1·52 mm. apart by rings of ebonite. The middle plate was silvered on both sides, the two others only on the side opposed to the middle plate. The capacity of the condenser, with air as dielectric, was 0·004364 microfarad, as determined from the dimensions, viz., 7,500 square cm. of surface, and 0·152 cm. space between the plates. The various dielectrics to be experimented on were poured into the trough. The galvanometer used was one of Wiedemann's construction.

The results of the experiments showed the truth of Faraday and Maxwell's theory. Dielectric polarisation occurs not only in insulators, but also in conductors. This was especially determined for conductors capable of decomposition. Dielectric polarisation has nothing in common with galvanic polarisation, since both phenomena can occur simultaneously in one and the same body. The exact values of the dielectric constants of conductors could

not be obtained by the author's method, but he can state that the dielectric constants of electrolytic conductors are quantities of the same order as those of true dielectrics.

The following table gives the values actually obtained by the experiments :

Liquid.	Full Discharge.		Initial value of Residual Discharge	Discharge after Momentary Charge.	Resistance.	Dielectric Constant.
	Air.	Liquid.				
Benzole, 1st Experiment...	4·50	9·94	0	...	∞	2·21
„ 2nd Experiment...	4·05	8·80	0	...	∞	2·17
Light Benzine	4·32	7·78	0	...	∞	1·80
Heavy Benzine...	4·49	7·64	Trace	...	3·34	1·70
Petroleum	4·95	10·12	Trace	...	4·64	2·04
Olive Oil	4·40	13·47	0·8	13·00	...	...
Oleic Acid	4·43	10·53	1·2	...	2·04	2·13
Ferric Chloride in Benzole	4·05	9·68	1·5	...	...	...
Oleate of Lead in Benzole	2·17	...	...	2·69	1·94	...
Ether, 1st Experiment ...	4·50	...	...	16·0	...	...
„ 2nd Experiment...	4·63	...	...	16·8	...	...

J. RUSSNER—COEFFICIENTS OF EXPANSION OF SULPHUR, INDIA-RUBBER, GUTTA PERCHA, AND PARAFFIN.

(Carl's Repertorium, B. XVIII., H. 3, pp. 152-177.)

The method adopted was that of Dulong and Petit. The body to be experimented on, the volume of which is known, or which can be calculated from its weight and specific gravity, is introduced into a glass vessel which is then drawn out before the blowpipe into a capillary tube. The apparatus is filled with water or mercury at a temperature t, and weighed. By subtracting the weight of the body and that of the vessel, the weight of the water or mercury is known, and from this the volume can be determined. The whole is then heated to a temperature t_1, and the weight of the remaining liquid obtained. From these data, knowing the coefficients of the vessel and of the liquid, that of the body can be calculated. The expansion of the mercury was determined from Bosscha's formula—

$$V_t = V_o e^{at}, \text{ where } a = 0{\cdot}00018077.$$

The expansion of the water was calculated from Rosetti's formula—

$$V_t = 1 + A(t - 4^o)^2 - B(t - 4^o)^{2{\cdot}6} + C(t - 4^o)^3$$

where A, B, C are very small constants.

The chief difficulty was to get rid of the film of air attached to the body. This was effected, where water was used, by prolonged boiling, and in the case of mercury by means of a Sprengel pump. To minimise any errors of observa-

tion large masses were experimented on, the apparatus being heated in a copper vessel containing about 5 litres of water, which was kept constantly stirred. The temperature was measured by a delicate thermometer.

Experiments on Sulphur.—A stick of sulphur was obtained by dipping a glass rod into melted sulphur and allowing the successive coatings to harden. From the experiments with water a mean value was found for one degree between 20° and 65°

$$\alpha = 0{\cdot}0010722,$$

which is correct to the fifth decimal. From the mercury experiments, between 17·7° and 62·7°

$$\alpha = 0{\cdot}0001725.$$

A third series of observations were made with sulphur crystallised from carbon bisulphide, from which the following formula was deduced :—

$$V_t = V_0 (1 + 0{\cdot}000128\, t + 0{\cdot}00000186\, t^2 - 0{\cdot}0000000153\, t^3)$$

From this formula the following values were obtained for one degree:—

at 10° ...	0·000147	at 40° ...	0·000178
at 20° ...	0.000160	at 50° ...	0·000183
at 30° ...	0·000170	at 60° ...	0·000186

Experiments on India-rubber.—A specimen of raw commercial rubber was used, and the two formulæ deduced—

1st. With water,

$$V_t = V_0 (1 + 0{\cdot}000636\, t + 0{\cdot}0000015\, t^2 - 0{\cdot}0000000174\, t^3)$$

2nd. With mercury,

$$V_t = V_0 (1 + 0{\cdot}000662\, t + 0{\cdot}000000242\, t^2 + 0{\cdot}0000000073\, t^3)$$

from which the following values are calculated for one degree :—

at 10° ...	0·000657
at 20° ...	0·000665
at 30° ...	0·000670

from which it appears that the increase in the value of the coefficient with increase of temperature is very small.

Experiments with Gutta Percha.—Purified gutta percha as used for insulating cables was employed, and the formula obtained,

$$V_t = V_0 (1 + 0{\cdot}000496\, t + 0{\cdot}00000496\, t^2)$$

from which were calculated for one degree—

at 1° ...	0·000501	at 30° ...	0·000646
at 10° ...	0·000546	at 40° ...	0·000695
at 20° ...	0·000595		

The coefficient of expansion is thus less than for india-rubber, but the increase for increase of temperature is greater.

Experiments with Paraffin.—The paraffin used was purified by filtration while

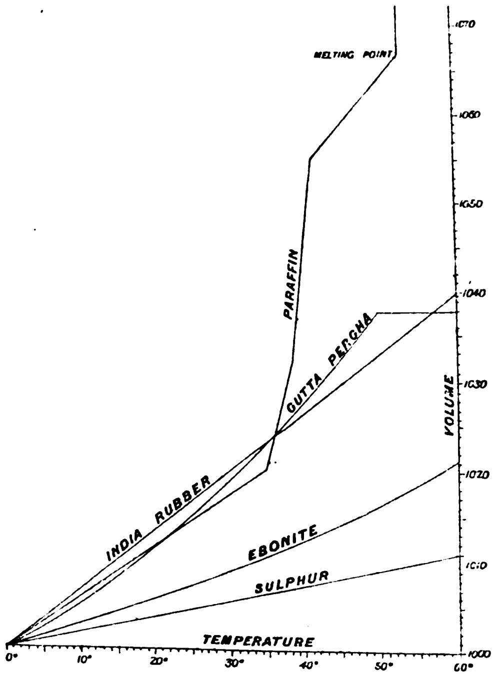
hot, and cast into thin plates from which pieces were cut. For temperatures between 0° and 33° the following formula holds good :—

$$V_t = V_0 (1 + 0{\cdot}000584\, t + 0{\cdot}000000992\, t^2)$$

Between 33·5° and 37·7° the coefficient for one degree is 0·0026, and between 37·7° and 41° it is 0·00666, while for temperatures between 41° and 52° the coefficient can be obtained from the formula,

$$V_t = V_{41} (1 + 0{\cdot}00115\, t + 0{\cdot}0000069\, t^2)$$

The general results of all the experiments are shown in the following diagram :—



K. F. SLOTTE—NOTE ON WHEATSTONE'S BRIDGE.

(*Annalen der Physik und Chemie*, *B. XV.*, *H.* 1, *No.* 1, 1882, *p.* 176.)

The following is a method by means of which the exact length of the platinum wire used in a Wheatstone bridge can be indirectly determined. Let s be the length of the wire, a and b the lengths of the two parts of the

wire, when a balance has been obtained with the two resistances r_1 and r_2; then

$$\frac{r_1}{r_2} = \frac{a}{b} = \frac{s + (a - b)}{s - (a - b)} = \frac{s + d_1}{s - d_1}$$

The resistances r_1 and r_2 are then exchanged, and a balance again obtained by shifting the point of contact with the wire. The amount of this movement, reckoned positively or negatively, accordingly as a is greater or less than b, is equal to d_1, which can therefore at once be read off on the scale. A comparison is then made of r_2 with another resistance r_3, and of r_3 with r_1, when, if d_1, d_2, d_3 are the values of the distances the contact point is moved, we have the three equations,

$$\frac{r_1}{r_2} = \frac{s + d}{s - d_1}; \quad \frac{r_2}{r_3} = \frac{s + d_2}{s - d_2}; \quad \frac{r_3}{r_1} = \frac{s + d_3}{s - d_3}$$

whence

$$s = \sqrt{- \frac{d_1 \, d_2 \, d_3}{d_1 + d_2 + d_3}}$$

In three determinations, according to this method, in which r_2 was taken equal to $\sqrt{r_1 \, r_3}$ approximately, the values found for s were 1,118·11, 1,118·75, and 1,118·6 mm.

JOURNAL

OF THE

SOCIETY OF

Telegraph Engineers and of Electricians.

VOL. XI. 1882. No. 41.

The One Hundred and Eighth Ordinary General Meeting of the Society was held on Thursday evening, 23rd February, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the previous meeting were read and confirmed.

The SECRETARY announced that since the last meeting donations had been made to the Society by Mr. Killingworth Hedges and Dr. G. Gore, and a vote of thanks was passed to those gentlemen for their presents.

The SECRETARY then read the following :—

10*th February,* 1882.

Dear Sir,

We, the Delegates nominated in 1878 to represent the Society of Telegraph Engineers and of Electricians at the Lightning Rod Conference, have the pleasure of reporting to the Council the termination of our labours, and of presenting herewith a copy of the report of the Conference.

It is not for us to express an opinion on the merits of the report, but we are glad to be able to state that it has, after most prolonged discussion, been adopted unanimously.

Thirty-nine meetings were held in all, and at every meeting one or both of us were present.

It will be evident, from an examination of the volume, that considerable expenditure has been incurred in printing and engraving. This has been done on the individual responsibility of some of the members of the Congress, and it is hoped that the sale of the report will cover the expense. It is desirable, therefore, to assist in the circulation of these reports as much as possible, and it has been agreed that the Delegates of each Society should ask their own Council to announce the completion of the work and its sale. This has been done as far as we are concerned, and it is hoped that the Members of the Council will do their utmost to favour the sale.

We are,
Yours faithfully,
LATIMER CLARK.
W. H. PREECE.

To the Secretary,
Society of Telegraph Engineers and of Electricians,
4, Broad Sanctuary, S.W.

Mr. E. Graves : I think that the members of the Society will hardly do their duty if they omit to record their thanks to the gentlemen who have represented them at the Lightning Rod Conference which has just been concluded. The report of the proceedings themselves sufficiently shows that careful forethought and reliable and trustworthy research have been devoted to the attempt to arrive at a conclusion that shall justify itself by its accuracy. Moreover, as regards our own delegates, here is one patent fact: twenty-nine meetings have been held—twenty-nine meetings have been attended; and I can assure you that that is no light labour for men who are occupied with many other things. One intimation is slightly foreshadowed: there is a possibility that the hope that "the expense of the publication of the report will be realised by the sale" may *not* be realised. Should that, unfortunately, be the case (I hope it will not be), I think that this Society, as one of the contributaries, may at least fairly be called upon to share the expense that has been incurred. However, trusting that the expense will be repaid by the issue, I can only ask you now to record a vote of thanks to Mr. Latimer Clark and Mr. W. H.

Preece, F.R.S., as our delegates, for their labours as representatives of the Society, and to Professor Ayrton, F.R.S., and Professor Hughes, F.R.S., their coadjutors. Other distinguished members of our Society also attended the Conference, but were acting as representatives of other Societies.

Mr. H. C. FORDE seconded the resolution, which was carried unanimously.

The SECRETARY then read the following paper on Siemens' System of Railway Gong-Signalling, by R. Von Fischer Treuenfeld, Member.

SIEMENS' SYSTEM OF RAILWAY GONG-SIGNALLING.

By R. VON FISCHER TREUENFELD, Member.

Mr. President and gentlemen,—In selecting Siemens' Gong-Alarums and Railway Telegraph Apparatus as the subject of my present paper, an apology has to be made for bringing before your notice a matter in which I personally have taken no part, either as an inventor or an improver, and also for introducing a subject which may not be new to you, and treats of a certain system of railway signalling used since 1847, and now most extensively adopted.

My only excuse for having chosen this subject is, that gong-alarums are comparatively little known amongst English railway telegraph engineers, and, as this apparatus is most extensively used among the signalling systems of other countries, it would not be amiss to lay it before our Society.

The reason why gong-signals are not used in England is obvious. In a thickly-populated country, with a great number of railway ramifications, on which trains follow each other in rapid succession, it is only natural that level-crossings should be considered extremely dangerous. The Board of Trade, therefore, under Act of Parliament, require railway companies to construct bridges over level-crossings, or other such works which remove or diminish the danger at these places. In fact, railway companies are not allowed to cross public thoroughfares unless empowered to do so by a special Act. If permission be granted, gates must be erected, and, as more than one gatekeeper must be employed at

each crossing, in many cases it would be cheaper in the end to erect bridges instead.

Gong-signals can find, therefore, but little application on English railways, where the existing level-crossings are mostly worked by the various block-systems in use. Nevertheless, there are places in England where gong-alarums would do good service; and I am sure that many of you, gentlemen, have heard of cases where trains have dashed into gates which were not opened in time, for want of proper signalling appliances. If it be true that English railways are not so much in want of gong-alarums, it is nevertheless the fact that Continental railways have found it absolutely necessary to use such signalling apparatus on a very vast portion of their lines. Where the distance between railway stations is great, and the line passes through flat and cultivated countries, a large number of level-crossings are unavoidable. It would not pay the companies to construct such a number of bridges, a proceeding which would be deemed still more impracticable where up and down traffic is conveyed upon a single line of rails. The cost of erecting and maintaining gates is not so great a burden to Continental railway companies, as the gatekeepers are permanently stationed at the gong-alarum houses, and perform the functions of linemen, besides attending to the gates. These houses are sufficiently large to accommodate the man and his family; and you will not unfrequently observe the wife acting as gatekeeper, while her husband is occupied with his duties as a lineman. From data which will presently be brought forward, you will acknowledge the great necessity for gong-signalling on single-line railways.

I maintain that such conditions exist, not only on Continental, but also on Colonial lines, and that this system would be quite as useful in India, Australia, Canada, etc., etc., as it has been and still is in France, Russia, Germany, Brazil, etc.

As gong-alarums are not used on the home railways, the non-introduction hitherto of gong-signalling into the Colonies is easily accounted for, as there is always a greater or less tendency on the part of Colonial residents to follow in the steps of the mother country. As a rule, the Colonial railways can be traced to English parentage, and it is only natural that these obedient children should imitate the customs of their venerable parent.

It seems to me, however, a question whether a little deviation from orthodox ideas would not benefit Colonial railways, particularly under circumstances which differ materially from those which exist in the mother country. There is no doubt that the Continental system of gong-signalling could be advantageously adopted on a limited scale, not only in Great Britain, but more especially on Colonial railways.

Alarum-gongs do not exclude the simultaneous adoption of any of the known block-systems, and in fact are often combined with such apparatus, but gongs are especially suitable for countries where a small population and little traffic make the more complicated block-system unnecessary.

A small house serves as a dwelling for the gatekeeper, and contains an electrical gong-apparatus. A given gong-signal, sent from the station at the moment the train starts, announces to the gatekeeper the approach of a train, and can be distinctly heard at a distance of 500 yards from the house; the gates of the crossing must then be opened, the optical signals put right, and points, bridges, tunnels, etc., as the case may be, looked over. The value of such loud bell-signals consists, therefore, in calling the attention of the gatekeeper a short time before the train arrives at that section of line which is placed under his care.

Visual signals or semaphores are not to be relied upon for this purpose, especially at night and in foggy weather, and they ought not to be considered sufficient to inform the gatekeeper of the approach of a train. Alarums, either single or double, with gongs of from 6 to 24 inches diameter, are placed at or near the house of the lineman, which is always close to the place where his attention is required. All alarums are connected by a telegraph wire, forming a separate circuit between each two railway stations.

The instruments of older construction, such as used since 1847, and exhibited at the London Exhibition of 1851, were composed of an electro-magnet, which, on being acted upon by the galvanic current, attracts its armature and frees the hook of a small hammer. This hammer, falling down, puts into motion the clock-work, which, moved by a weight, makes one or two heavy bell-tongues strike against one or two large gongs. The movement of

these tongues is automatically stopped by the same clockwork, and the small hammer which dropped down is also lifted up again, and hooked to the electro-magnet, ready to put the clockwork in motion as soon as another current passes through the bobbins of the electro-magnet.

Fig. 1 shows the section of a gong-house, with a double-bell

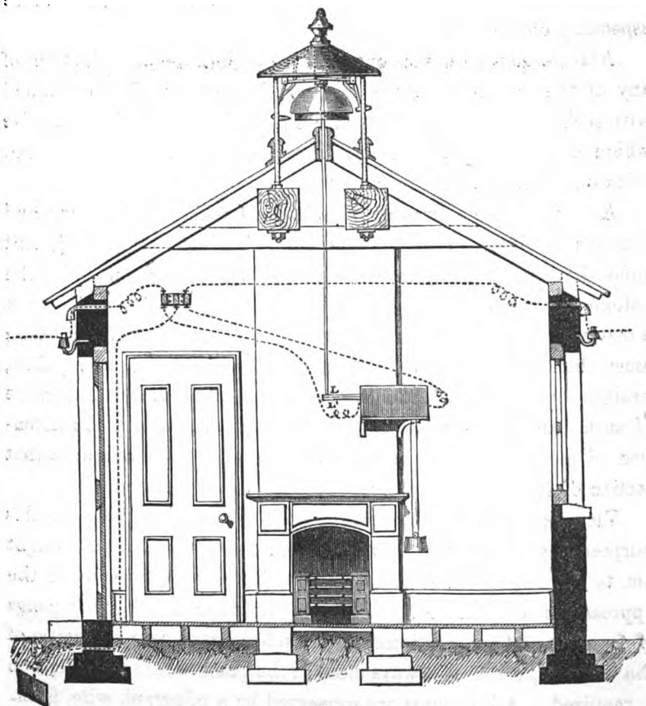
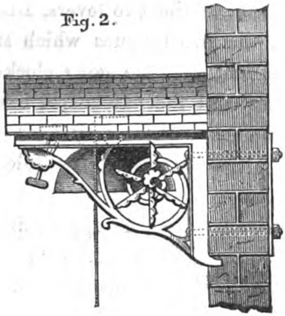


Fig. 1.

apparatus fixed on the roof, and the clockwork inside the house. Fig. 2 shows a single-bell apparatus on brackets attached to a wall: others of similar construction are often used, varying in the number of gongs, their diameter, and in the way of attaching them to walls or supports. Fig. 3 shows the side elevation of the older system of clockwork. The drum and wheel, P_1, is moved by means of a weight. P_1 has projecting pins, KK . . ., which act upon the

levers, LL, moving them alternately up and down, and the latter, being attached to the tongues of the bells, produce the required beats. P_1 also moves the wheel, P_2, which turns the regulating fan, F. On the axis of the drum is fixed an eccentric, E, with an arm, O_1, carrying a tongue, O, which is caught by the tongue, *p*,

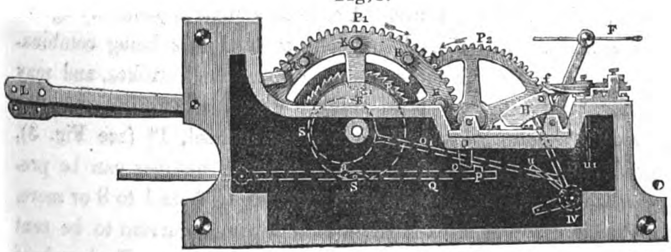
Fig. 2.



of the lever, Q, as long as the small hammer, H, does not rest on Q. This hammer, H, turns on the spindle, IV., and is kept in its upper position by the pawl, *f*.

The electric current sent from one railway station to another passes through all the electro-magnets of the gong-apparatus, attracts the pawl, *f*, and frees the small hammer, H, which

Fig. 3.



falls and presses down the lever, Q, and its tongue, *p*. This latter frees the lever, O_1, the drum begins to rotate, and the bell tongues strike against the gongs. To limit the number of strokes, the hammer, H, is arrested automatically in the following manner:—The arm, O_1, after the eccentric has nearly finished one revolution;

moves a fork which turns on the spindle, IV., and thus raises the hammer, H, till it is caught again by the pawl, *f*; at the same time u moves to u_1, and the indentation, *a*, of the revolving plate, S, allows the pin, *a*, of the lever, Q, to ascend. This latter in its progress arrests the arm, O_1, and stops the striking of the gong. As shown in Fig. 1, the ends of the two levers, LL, are connected by means of cords with the two tongues which strike the bells on the roof of the gong-house. The gong clockwork is generally placed inside the house, and the gatekeeper has only from time to time to wind up its weight. There may be a special battery for this alarum circuit, or the battery of the telegraph instruments may be used.

A separate line-wire for the gong-apparatus, and another wire for telegraphic communication with its own battery, are recommended. Should economy be of importance, the telegraphic correspondence could be carried on through the alarum wire. The current for telegraphic correspondence would in such cases pass through all the electro-magnets of the clockwork apparatus, its strength being so regulated as not to attract the armatures, but still strong enough to work the relays at each station. A stronger current is sent into the line by a key, which frees the clockwork, and consequently strikes the gongs. The use of a key enables the sender to transmit a variety of signals by striking the bells once, twice, or more times. A code of signals is generally agreed upon, and a few are found sufficient, such signals being combinations of one, two, or more groups of loud bell strokes, and may mean "up train," "down train," "stop all trains," "twelve o'clock," etc. Each revolution of the wheel, P^1_4 (see Fig. 3), produces a definite number of strokes, which number can be prearranged, according to the number of pins, K, from 1 to 8 or more, and each group of strokes requires a separate current to be sent into the line with the key of the stronger battery. Clockwork of different sizes and construction is used with gongs of cast-iron or steel, from 6 to 24 inches diameter, etc. This first form of gong-signal lines, although still in use, contains many points open to improvement, viz.—

1. The electro-magnets, being worked by galvanic batteries,

were subject to unavoidable irregularities: a change in the strength of the batteries, a contact with the line wire, an increase in the moisture of the air, all tend to weaken the current, and the armatures of the electro-magnets, being adjusted to a certain strength of current, will either give way (if a closed circuit be used), or the battery current sent into the line to attract the armatures may be too weak to fulfil its mission. The clockwork had consequently often to be adjusted, in accordance with the strength of the battery current.

2. The starting of the clockwork depended on the action of one impulse of current, or one interruption of a current. Such apparatus not only requires delicate, but also frequent adjustment, in consequence of the changes in the strength of the current. The instruments, if not well adjusted, will either cease to work, or give signals at wrong times, and these repeated adjustments are, if not impossible, at least very inconvenient.

3. All electrical signals produced by the action of *one* current, or by *one* interruption of a current, are liable to be influenced by atmospheric electricity, as thunder-storms, aurora borealis, earth currents, etc., and so endanger the safety of the traffic.

4. The armature of the electro-magnet was liable to fall off when shaken, and thus cause the clockwork to strike the gongs unnecessarily. This has occurred when heavy trains passed, and the electro-magnet was not properly adjusted.

These faults have been remedied by the introduction of considerable improvements, viz.—

1. All faults in railway gong-signalling, arising from the use of batteries, have been eliminated by the employment of powerful and constant magneto-electric inductors instead of batteries. The magneto-inductor does not change its strength, and therefore the gong-apparatus, when once adjusted to the strength of the current from the inductor, never requires readjustment. Powerful magneto-currents are not perceptibly influenced by changes of atmospheric moisture, and consequent leakage of the line. With Siemens' gong-signalling system, batteries are only used for telegraphic correspondence, and, as the receiving instruments are always in the hands of telegraphic clerks, any irregularities in the wŏrking of these instruments and the batteries can easily be adjusted.

The magneto-inductor, Fig. 4, consists of a series of 12 permanent magnets, between which a Siemens armature revolves when the handle of the inductor is turned.

Each complete revolution of the armature produces two currents in opposite directions in a coil of insulated wire, forming part of the cylindrical armature. One revolution of the handle causes the armature to revolve 13 times, and consequently 26 currents, alternately positive and negative, are generated in the insulated wire coil during this time, and are sent into the line wire.

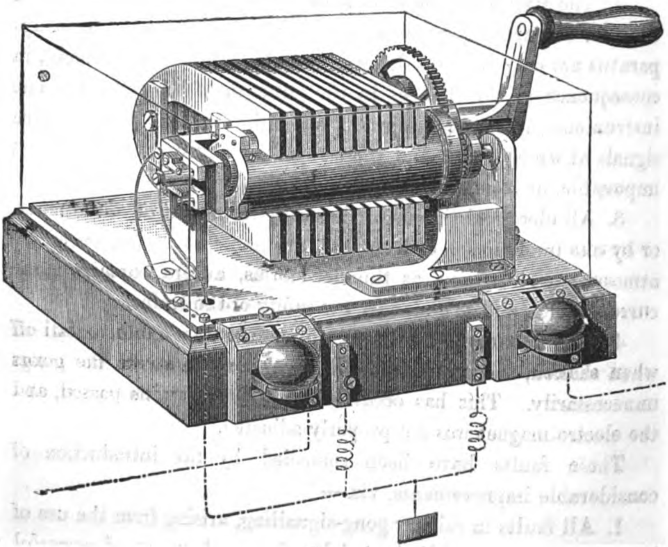


FIG. 4.

The apparatus has two keys or plungers, 1 and 2, one for the up, and the other for the down line, so that one magneto-inductor is sufficient to send currents in either direction, by pressing down key 1 or 2, and turning the handle at the same time. If a gong-signal has to be given, the operator at the station presses down the corresponding plunger and turns the handle of the inductor, thus sending a number of alternately positive and negative currents into the line, freeing the clockwork of all the alarum apparatus simul-

taneously between his and the advanced station. Inductors of this description are used in great numbers on railway lines, and have everywhere given satisfaction. Their advantages may be summed up as follows:—

(a) The removal of batteries, and avoidance of all inconveniences connected with the use and maintenance of battery cells.

(b) The currents from a magneto-inductor excel those of batteries, and therefore act more energetically upon the armatures of the electro-magnets: these latter can be more firmly adjusted, and there is consequently no fear of an untimely dislodgment of the clockwork and bell tongues.

(c) Although the first expense of an inductor is greater than that of a battery, the former proves, nevertheless, the cheaper in the end, as there are no expenses for cleaning and maintenance. The inductor occupies very little space, and can be easily placed and removed. On the whole, it simplifies the service and gives a greater guarantee for the exact transmission of signals than that obtained when batteries are used.

2. As mentioned above, all signal apparatus depending on one impulse of a current, or one interruption of a current, require delicate and frequent adjustment, and are liable to give untimely signals or to cease to work. These inconveniences are set aside in Siemens' gong-signalling system, by making the signals depend on the action of a series of alternating magneto-electric currents. The armatures of the electro-magnets are caused to oscillate by a number of successive currents, alternately positive and negative. An escapement is attached to these armatures, similar in action to the anchor-escapement employed in clocks: this escapement acts upon a toothed segment, which, after being raised to a certain extent, frees the clockwork and causes the striking of the gongs. Thus a number of successive currents, alternately positive and negative, are required to produce a number of armature-oscillations, which raise the segment and free the clockwork.

Fig. 5 shows a side view of a spindle-alarum, mounted on an iron column, and Fig. 6 shows a side view, with details of the electro-magnet and toothed segment for releasing the spindle.

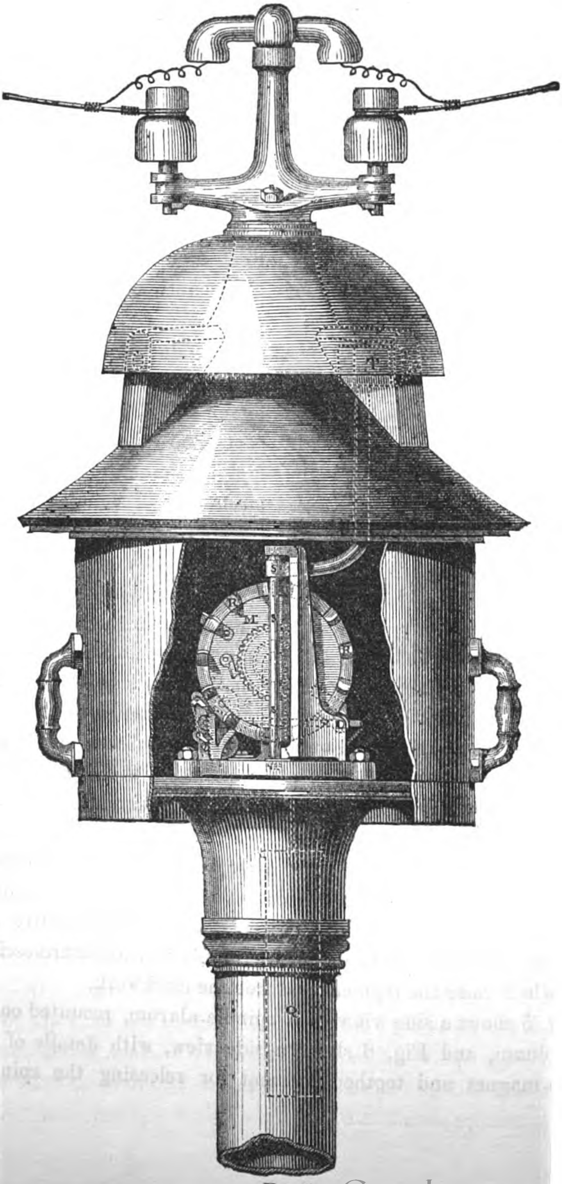


FIG. 5.

a is the segment which turns upon its axis, B, and is held upwards by a spring, C. EE is an electro-magnet, between the poles of which one pole-end of a permanent magnet, H, oscillates with its axis at G. To the magnet, H, is attached a piece, K, with two spring pawls, LL, engaging with the teeth of the segment, *a*, which latter ascends half a tooth at each single oscillation of K; the axis, B (the half shown black being cut away), is thus turned, so that a thumb, D, of the drum, M, is enabled to clear it. M, being influenced by a weight, rotates in the direction of the arrows, until a pin, N, which rotates with M, reaches the arm,

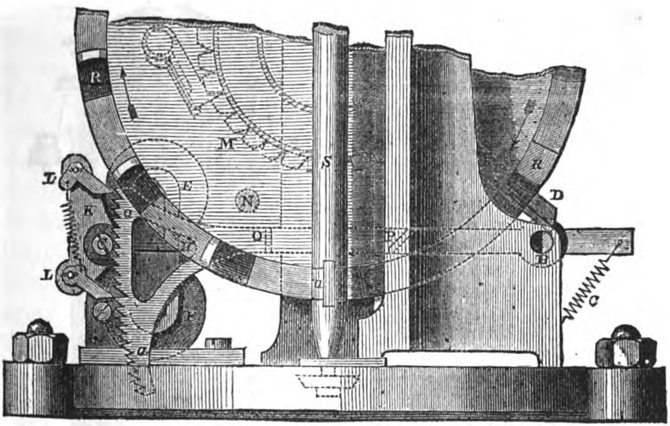


FIG. 6.

OP, of the segment, *aa*, and forces the same down again, the spring pawls, LL, allowing the segment to pass them. The drum continues its rotation until it is stopped by the thumb, D, resting as before upon that part of the axis, B, which is not cut away. The striking gear is shown in Fig. 5. The weight, Q, is suspended inside the pillar, and gives a rotary motion to the drum, M; the latter carries on its face a number of teeth, RR . . . , which strike successively projections, *uu*, at the ends of the spindle, SS, and cause it to swing to and fro. A hammer, T, attached to the spindle, S, and passing through an opening in the roof which covers the apparatus, strikes against the gong. Gong-

apparatus, as here described, may be combined with block-signals, or worked without them.

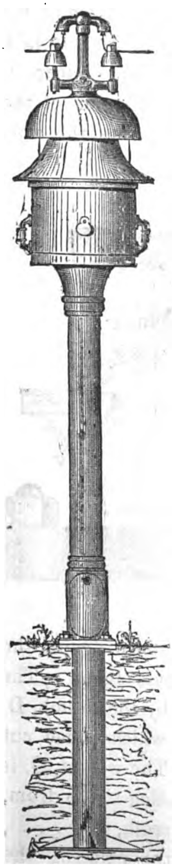


FIG. 7.

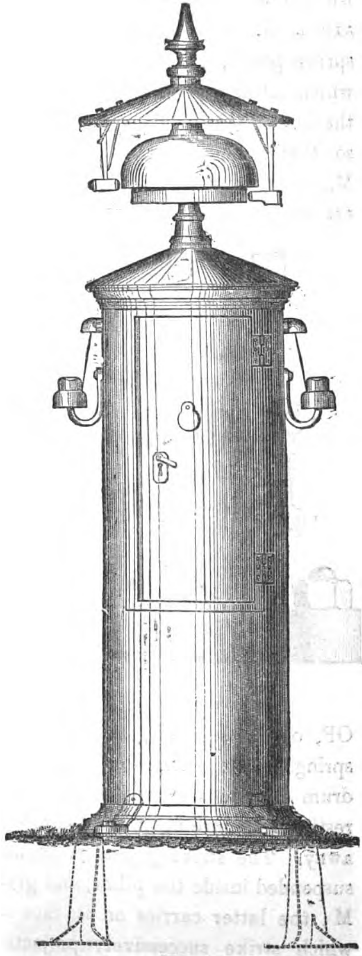


FIG. 8.

3 and 4. Siemens' Railway Gongs, being so constructed that a number of successive currents, alternately positive and negative, are required to produce a signal, cannot be influenced by accidental

currents from atmospheric electricity, earth currents, line-contacts, etc., and, however much they may be shaken when heavy trains pass, an untimely or wrong signal is impossible. Two operations being required to produce a signal, viz., to turn the handle and press down one of the plungers of the inductor, signals could not be given by only touching the generator or pressing down the plunger.

Sometimes the alarum lines do not run from one station to another, but only reach intermediate points which require special protection, and gongs are often used as distant signals to protect the entrance of terminal stations and junctions. Signal houses are not always required, and the gongs are placed on iron columns, such as shown in Figs. 5, 7, and 8, with either single, double, or triple bells. Simple alarum lines, as described above, and consisting of gong-apparatus and a battery, or gongs and a magneto-inductor, form for themselves a perfect signalling system, and are often used quite independently of any other signalling or telegraphic combination. In many cases, however, the alarum line is combined with a telegraph line-wire, and in other cases the alarum apparatus is provided with additional parts, which allow a greater variety of gong-signals, and permit the sending of telegraphic messages from any *one* gong-apparatus to *both* adjoining railway stations.

It is important that signal lines should be of simple but reliable construction. The object of railway signalling and telegraphy being principally to attain a well-regulated and safe guidance of the trains, telegraphic communication should not be permitted on signal lines, because intermediate stations would be excluded at times from the immediate reach of an electric call or signal. Notwithstanding the possibility of using one signal line wire for telegraphic communication and alarum-signals, it is undoubtedly better to have two separate wires between the stations, one for speaking purposes, and the other exclusively for line-signals, either bell-alarums, block, or other signalling combinations. Should the traffic require a direct communication between terminal stations, or between far-off end and intermediate stations, a third wire may be used for this purpose. Leaving aside, however, the necessity of a third wire for direct communication, we distinguish the two following lines:—

(I.) Correspondence or telegraph line.

(II.) Alarum or signal line.

(I.) For telegraphic communication between stations, recording-instruments are recommended, with relay, galvanoscope, key, lightning discharger, and commutator (see Fig. 9), mounted with "spring contacts" on a specially-constructed table with the necessary wire connections. These tables are all made of exactly the same pattern, so that the instrument of one table-board fits into the spring contacts of a board at any other station. It is advisable, and also very convenient, to have all instruments placed

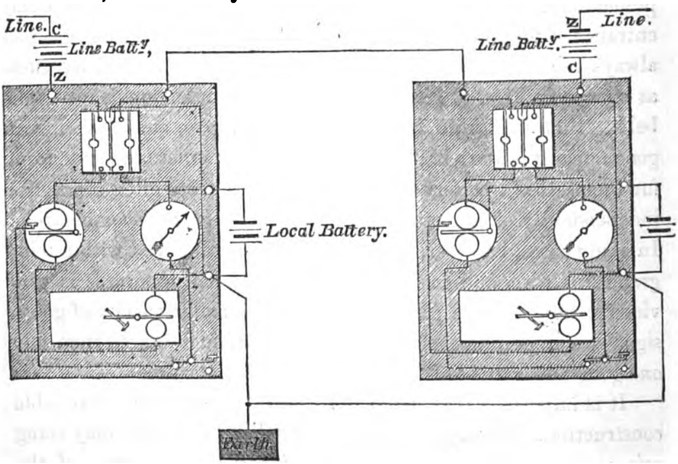


Fig. 9.

upon the tables in such a manner that any apparatus out of order may be removed without interrupting the line. This object has been attained by placing them between spring contacts, which close automatically when an instrument is removed, thus always maintaining the continuity of the circuit, and only excluding that special instrument.

The telegraph apparatus is sometimes placed on a cupboard instead of a table, and the batteries are protected in the cupboard under the instrument.

Any instrument can be replaced on these table-boards by a person who has no knowledge of the electric connections, and

without the use of tools. The faulty apparatus can then be forwarded to the central station for repair, and, should no spare instrument be at hand, a new one can be sent and placed, without the assistance of a telegraph inspector or mechanic, and without interruption of the electric circuit.

Tables with spring-contact boards have all the wires arranged, so that they can be used at either terminal or intermediate stations. The polarised relay is used with the closed-circuit system, and for working this latter Daniell's elements are the best. In the general plan exhibited, the telegraph-correspondence line is not shown, but only the connections of the alarum-line, with gongs mounted on pillars near crossings, etc.

Fig. 9 shows the connections of an intermediate telegraph correspondence station, which are of the usual description, and need no further explanation.

AA in the general plan is the table containing the apparatus to send gong-signals, and to receive signals for help from signal-houses (as will be explained hereafter). It is judicious to provide all gatekeepers with means for giving telegraphic signals for help from their houses to the nearest railway stations, with a view to prevent a foreseen mishap, or to ask for help in case of an accident. Siemens' Gong Alarums possess special arrangements for sending signals for help automatically from the gong to the nearest stations, where the signals are received by a polarised station-bell, B, or recording instrument, or by both. The receiving apparatus is shown in the plan on the table, AA, and consists of a normal inker, galvanoscope, key, and lightning discharger. A commutator and two station-bells on an iron stand can be added to the above, and also a pedestal with a pedal, by which the apparatus is switched without using commutator pegs.

As soon as a signal for help is received by one of the station-bells, the operator puts his foot on the pedal, and by doing so he receives the signal on the paper strip of the recording instrument, because the pedal not only switches the *recorder* into the circuit, but also an *auxiliary local battery*, which augments the current from the closed-circuit battery. The polarised station-bells are so adjusted that the armatures always fall towards that pole of the

electro-magnet which is opposite to the pole against which they are held by the closed-circuit current. Consequently, when this latter current is interrupted, the polarised armature connected with the bell-tongue is drawn towards the opposite pole, and strikes the bell once, and on the *closing* of the current, *another* stroke is given on the *other* bell, as the armature is restored to its normal position. The pedals perform the same operation as if the switch levers were turned. As soon as the foot is removed from the pedal, the recorder is switched out of the circuit, while the station-bell and galvanometer are always connected with the line. This pedal switch renders it impossible either to *make* or to leave wrong con- nections. The recording instruments of the alarum-line are the same as those of the telegraph-correspondence line, and *both* can be exchanged. The mageto-inductor is usually placed on the table to the left of the recording instrument, and is made to give 2, 3 6, 9, or 18 strokes for one turn of the inductor handle, and a variety of signals can be arranged, by turning the handle once, or any number of times, with an interval between each revolution Supposing the gongs are struck twice, • •, at each separate turn of the inductor handle, the following signals may be convenientl combined :—

One turn to mean train in "up direction"—• •
Two turns in "down direction"—• • • •
Three „ trains stopped—• • • • • •
Four „ twelve o'clock—• • • • • • • •
Seven „ stop all trains—• • • • • • • • • • • • • •

These signals are heard simultaneously by all the gatekeeper between two stations, who are thus informed of the departure of train, its direction, etc., and can attend to their duties in prope time. "Signals for help" may be given from any of the signal houses to the nearest stations. This is done in the following manner —The alarum wire not only conveys the magneto-electric current required to ring the gongs, but a closed-circuit battery-current also continually passing through that wire, and all intermediat gong-alarums and station-bells of tables AA. The course of th magneto-electric currents is shown in the plan in dotted lines and that of the closed-circuit battery-current in full lines; bot

currents passing on the same alarum-wire. A small station-bell, B, or if preferred, also a recording instrument (embosser or inker), M_1, is placed into the battery circuit. The closed-circuit current, passing through all the bobbins of the gong-alarums, does not act upon the armatures, which can only be worked by a series of alternating currents. By means of simple mechanical arrangements, hereafter explained, a contact-wheel can be set in rotation by the signalman in such a way that it interrupts the closed circuit of the alarum-line at greater or less intervals, ringing the small station-bells, B, accordingly. The normal position of the switches, SS, of all instrument tables, AA, is at *m*, thus connecting the bells, BB, direct to the earth. By switching S over to *n*, the signals for help are recorded by the inker, M_1; each gong-alarum apparatus contains several automatic contact-wheels, each wheel representing a certain

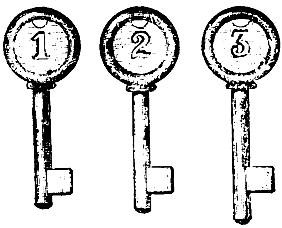


FIG. 10.

"signal for help." Six or eight "signals for help" are generally considered sufficient to meet the ordinary requirements of the service. The signal is given by simply putting a key corresponding to the number of the desired signal into the key-hole of the spindle-alarum, and turning it round once. By inserting a key, the contact-wheel rotates mechanically, and the length of the key determines the message or call for help to be sent. (These keys are shown at Fig. 10.)

In the improved gong-alarums, the keys have been abandoned, and the contact-wheels (Fig. 11), generally five in number, each representing a signal for help, are respectively placed on an axis and set in rotation, whereby the current is interrupted, and the signals transmitted.

In sending a signal for help, the spindle-alarum has simply to be kept rotating, until the answer is received from the adjoining stations, that the signal has been understood.

This answer is given with the magneto-inductor, and all the gongs along the line where the mishap occurred ring, thus warning the men of that section that some signals for help are being exchanged.

The automatic contact-wheels are made of various shapes: for instance, No. 1 in Fig. 11 shows one which interrupts the closed

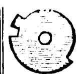
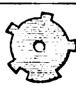
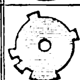
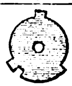
No.	Contact-wheels.	Signals for help.	Signification of Signs.
1		— -	Engine broken down.
2		— — —	Train off the Line.
3		— — — — -	Auxiliary Engine wanted.
4		— — — - -	Stop all Trains.
5		— — -	Men and Doctor wanted.
6		— — — -	Train must be taken back.

Fig. 11.

circuit for one long and one short interval, during which interruption the station-bells ring, and the recording instruments mark one long and one short dash, showing the letter N, for each revolution of that contact-wheel.

Fig. 11 shows 6 different contact-wheels, their signals registered by the recording instrument, which are similar to the interval at which the bells ring, and the signification of such signals.

It is necessary that the stations should know from which place signals for help are coming. This is done by giving a number to each signal-house. The alarum-apparatus contains a special contact-wheel which, when brought into rotation, sends its number to the nearest stations, thus informing them where the mishap occurred. This number is always given after the signal for help has been received and acknowledged by the corresponding stations. As a rule, numbers are formed in the following manner:—

1 = •
2 = • •
3 = • • •
4 = • • • •
5 = —
6 = • —
7 = • • —
8 = • • • —
9 = • • • • —
10 = — — etc., etc.

Thus, by inserting certain keys into the gong-alarum apparatus, or by placing the contact-wheels in circuit, the men are enabled to send telegraphic signals, whereby they may call for assistance, or notify danger to the neighbouring stations. A commutator, shown in Figs. 12, 13, and 14, is sometimes attached to the gong-alarum apparatus and places the contact wheels out of circuit until they are required to send signals for help. Fig. 12 shows this commutator in combination with a gong-clock-work, similar to that shown at Fig. 3, but they are also attached to spindle-alarums, such as shown at Figs. 5 and 7. The commutator consists of a small square box, with four terminal screws carrying two brass connecting bars. Each of the four terminal screws is connected to one leading wire, shown in Fig. 12, which also shows the contact-wheel and spring out of circuit, as long as the connecting bars stand horizontally; but if the bars are shifted in the manner indicated by the dotted arrows (Fig. 13), so that they stand perpendicularly, as shown in Fig. 14, then the contact-wheels and contact-spring are included in the closed circuit. A transmitting key may also be attached to the

commutator, as shown in Fig. 12, and brought into the circuit,

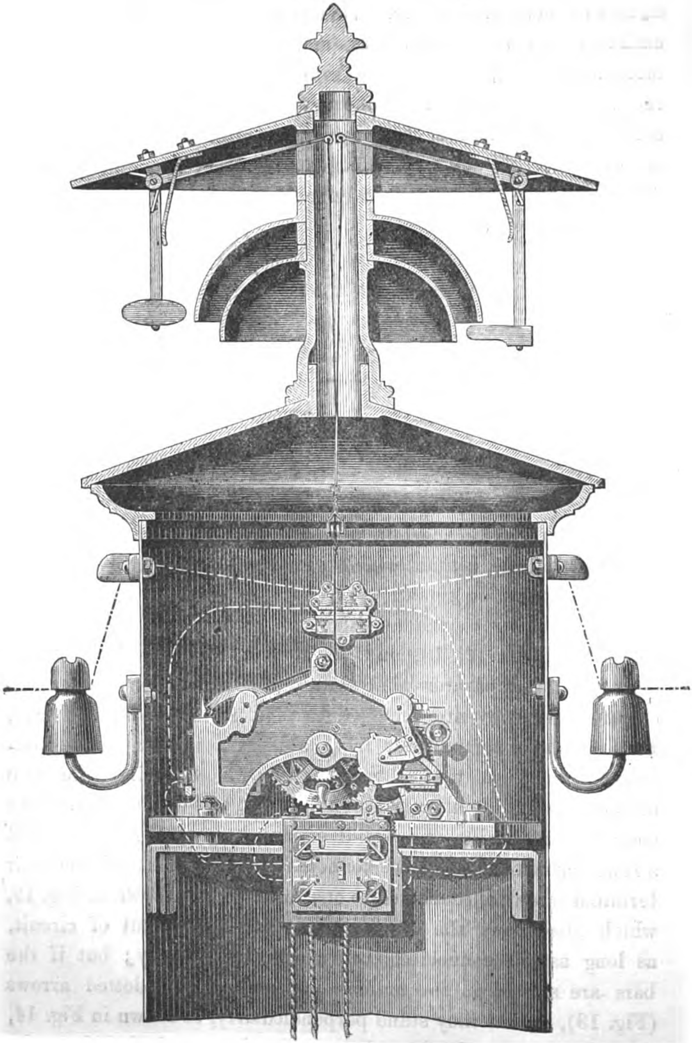


FIG. 12.

thus enabling telegraphic messages to be sent from any of the gong-alarums to the stations.

The leading principles for the selection of a system of railway telegraphs are distinct from those of ordinary telegraph lines. Railway telegraphs must satisfy special conditions of traffic and management, and their first object is to ensure the security of such traffic. The functions which different railways demand from their telegraphs are variable, and the systems adopted are necessarily of a varied kind. This makes it impossible to describe a system which would answer in all cases, and the apparatus above described are only given as samples which may facilitate the formation of a system for any given case.

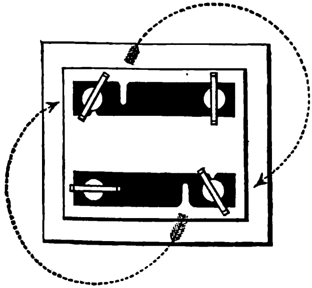


Fig. 13.

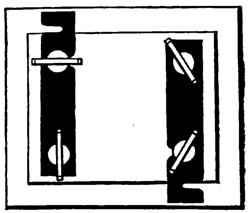


Fig. 14.

Before finishing my description, I beg to mention a few accessory railway-telegraph apparatus, which are often used in combination with the gong-signalling system, viz.:—

Station Bell Alarums.—Bell-signals between two stations, or between two localities at one station, are often given by small magneto-bell inductors. The inductor, including its own bells, is 11 × 6 × 12 inches, and to give a signal it is only required to turn a handle. In cases where signals are received at one end, only one instrument is required; the alarum-bells are then separated from the inductor and placed at the receiving end, while the inductor remains at the sending end.

Signal-House Telegraph Apparatus.—Signal-houses are sometimes provided with telegraph apparatus of special construction (shown in Fig. 15). Each instrument is enclosed in a wooden protecting case (as shown in Fig. 15*a*), which, when shut, short-circuits the recorder automatically by two spring contacts,

dd, and, when opened (as shown in Fig. 15), includes it in the circuit of the alarum-line. The protecting cover is generally closed, thus keeping the recorder out of circuit, and only using it on special occasions, when telegraphic correspondence between signal-houses and stations becomes desirable. The folding cover, U_1, serves as a writing-desk, and the apparatus is a comple recorder,

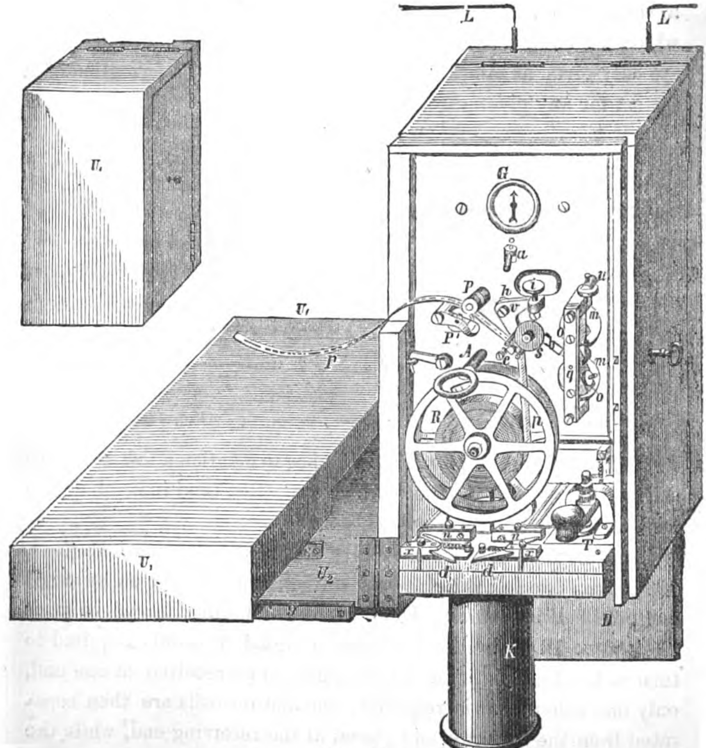


Fig. 15.

with a key, T, galvanoscope, G, and paper-wheel, R. It is set in motion by a weight, K, which is wound up by a key, A. The messages are received upon a paper strip, P, by either a blue pencil disc, S, or an ordinary ink-trough arrangement. These recorders, stationed at intervals along the line, replace the portable

recording-apparatus (Fig. 16), also used on many railways, and carried in the guard's van. The former apparatus has the advantage of greater reliability, being always ready for use, whereas the portable recorder must first be placed into circuit, which operation, in the excitement of the moment, may be carried out wrongly, or the portable recorder may itself be damaged during an accident.

Portable Telegraph Recorders are also often carried in the

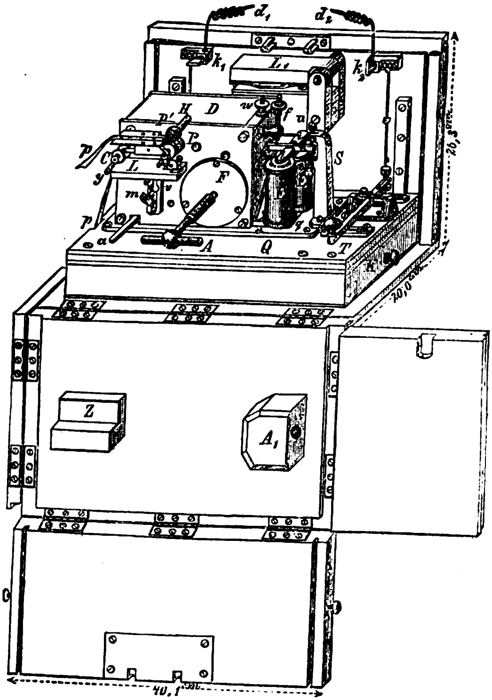


Fig. 16.

guard's van, in case of an accident, breakdown of a train, etc., etc. Fig. 16 shows one of these portable railway apparatus, placed in a protecting case with folding boards. The winding-up key, A, of the spring drum, F, is taken off before closing the protecting case, and is kept in the block, A_1. The paper disc is in a drawer, K, beneath the apparatus. Two leading wires, d_1 and d_2, connect the appa-

ratus with the line wire. Before the protecting case is closed, the ink bottle, L, is unscrewed at *mv*, and placed in a case, L_1, attached to the back of the folding case, and so arranged that the ink is prevented from running out.

Although the first Siemens' Gong-Alarums were constructed and tried as early as 1847, it is only since 1852 that this signalling apparatus became extensively used. From the year 1852 till 1881, such alarums, clockwork-gongs, and spindle-gongs were adopted by 96 railway companies, having in actual use a total number of 40,000 railway gongs, extending over France, Germany, Austria, Russia, Holland, Belgium, Denmark, Switzerland, Norway, Sweden, Brazil, and Chili.

Besides these, a considerable number of gong-alarums are employed for other than railway purposes, such as signalling in mines, alarums for fire-telegraphs (Shangai, Amsterdam, etc.), and in factories, etc.

The above numerical statements, which in fact are rather under estimated, speak for themselves as to the efficiency of gong-signal alarums, but a few words from official sources may not be out of place here.

The French Government, after a series of railway accidents, ordered a special Commission, not only to enquire into the causes of railway accidents, but also to examine the existing signalling systems, and express their opinion as to the best means for materially reducing the number of such casualties. A committee for this purpose was formed on the 29th August, 1879, by order of the Minister of Public Works, and consisted of seven public inspectors of railways. They examined 218 systems, among them being the gong-system.

With reference to level-crossings, they say in their report that, "as an alarm apparatus of great security, we have the German gongs of Siemens' system, which give an increase of security to the traffic, to be preferred to that which could be attained by means of the telegraph." And further: "The gong-apparatus are generally considered of a more practicable application and of an efficiency which has been proved a long time since in Germany, Austria, Italy, Holland, etc., where they became generally used." Relating to the

utility of these gongs, where gatekeepers are employed, the report says: "Even on lines where they have been to a certain extent abused, by employing them for the purpose of transmitting a great number of special signals, they have never *caused*, but, on the contrary, often *prevented* accidents."

The Commission report to the Minister their conclusion, and recommend the adoption of gongs as an auxiliary system, the most practical and useful for augmenting the security of railways consisting of a single line of rails, and where more than 6 regular trains run in each direction during the 24 hours. The Commission is further of opinion that the railway companies ought to be requested to gradually adopt either electric gongs, or, if they prefer it, a block-system combined with the out-door semaphores.

Therefore the Minister of Public Works, accepting the above reports, decreed the compulsory adoption of railway gongs by the companies, on all single lines with a traffic of more than 6 trains in each direction during the 24 hours.

I hope, gentlemen, that the paper which I have the pleasure of laying before you, although it may not be of great use on English railways, may be of value to those members of our Society who are connected with this branch of the engineering profession in our Colonies or in foreign countries.

Extract from "Journal Officiel de la Republique Française," Sept. 21st, 1880.

En m'y référant, je crois devoir, conformément à l'avis de la commission d'enquête, vous prescrire de prendre des mesures pour appliquer progressivement, d'ici au ler Janvier, 1882, sur les sections à voie unique où circulent plus de six trains régulier par jour, dans chaque sens, l'un ou l'autre des systèmes indiqués cidessus (cloches électrique dites allemandes, ou block-system à signaux exterieurs)."

(Signed) MINISTER OF PUBLIC WORKS.

After the paper was read, Mr. Treuenfeld practically demonstrated the working of the system, described by means of a complete set of apparatus exhibited before the members.

Mr. C. E. SPAGNOLETTI: The paper which Mr. Von Treuenfeld has given us to-night is a very interesting one, particularly to those connected with the working of lines of railway, and more especially to those connected with the electrical department. The instrument described is a complete and very ingenious one:

the many ways in which it is brought to bear to carry out the objects in view are excellent, and only what might have been expected from the great firm of Siemens Brothers. One question which has not been touched upon in the paper is that of expense. It would be interesting, if Mr. Treuenfeld could inform us, to know what would be the cost of apparatus of this kind to fit up, say, 100 miles of railway, with 50 intermediate signalling points upon it.

One drawback, I fancy, in the arrangement, is the clockwork. It has always been the endeavour of workers in this field to avoid entirely any arrangement which should be dependent upon the performance of a certain duty by the man in attendance, and any system so constructed has always been looked upon as of little value for the purpose intended. This system only gives an audible signal: we have also always tried and prefer to get visual signals. Audible signals are only transitory, and are likely to be forgotten by a man who may be busily engaged with the shunting of trains at a large yard, unless he can refer to a register or visual signal at any time to see whether the line is clear or blocked.

The gong-system is perhaps more applicable to Continental than Home Railways, because, as Mr. Treuenfeld has told us, the trains are comparatively few and far between. The stations, also, are further apart than they are in England; and, to obtain the full value of the block-system, the distances between the stations should be as nearly equal as possible, and therefore where long distances exist between them, and a level-crossing occurs conveniently midway, or nearly so, an intermediate block station is established, and the man who attends to the crossing can also attend to the signalling apparatus. By dividing the railway into short sections, the greatest possible facilities the block-system can offer are ensured.

Again, an instrument by which messages can be sent is mostly connected with the block apparatus, so that messages in full can be sent, which, I think, is better and more advantageous than simply giving one, two, or half a dozen codes, because a signalman can say exactly what is wanted, and ask for any assistance required. One wire also performs the dual purposes of the gong

and speaking instrument, whereas, in the apparatus before us, with a speaking instrument two wires are required. What is required in this country more than anything else is uniformity in the bell-code signals used on all lines. Very great diversity of practice at present unfortunately exists. The running of through traffic from one line to another is getting so much into fashion, it is most desirable, and indeed necessary, that the signals on all lines should be uniform, and when that is brought about great satisfaction will be felt by the change. The bell-code signals should be arranged so that their brevity might represent their importance, especially for the imperative ones. For instance, if from any cause an advance station, after having given permission for a train to come on, should wish to stop it, an immediate and urgent signal is required to be sent, and that signal should be as short and concise as possible, on account of the limited time in which to send it, to be effective. After this, those most used should consist of the least number of beats for convenience. Too many beats are frequently employed for signals, and that is a matter which is receiving the constant attention of railway officials; and, from my connection and contact with many of the leading officers of the various railways, I can testify to the great care and anxiety always given in considering matters relating to the safe and efficient working of the traffic, and that safety is the first point always looked to. I have figures here which show how successful the improvements in railway working have been in preventing accidents and loss of life. In England and Wales, in 1880, there were over 541,000,000 passengers carried, in Scotland there were 45,000,000 to 46,000,000, and in Ireland there were 17,000,000, making a total of 604,387,199 passengers. The train miles run in that year were over 122,000,000 miles, and we find the average number of persons killed is 1 in 4,252,704. These figures are very satisfactory, and show how many people are safely carried over all parts of our country. In the number of passengers, the companies' servants and people who ride other than as ordinary passengers, such as attendants on cattle and horses, are not included. On our railways the traffic is very great and varied. Besides special, express, and ordinary

passenger trains, there are special, fast, and slow goods trains, running at various speeds, intermixed on all parts of a railway, rendering an effectual block-system absolutely necessary. Improvements are continually being made, the latest being the physical locking of signals at stations from the station in advance by an amplification of the slotting arrangement, carried out electrically, and where at crowded points and large shunting yards a man at either end can check the man at the other end. I think great results will be obtained from the introduction of a system of this kind. It is now under the consideration of many of the companies, and some are trying it with very satisfactory results.

Mr. W. H. Preece, F.R.S.: It is now twenty-eight years since I was first engaged, as an assistant to Mr. Edwin Clark, in establishing electric railway signals on the London and North Western Railway, and it is exactly twenty years since I read a paper in this very room, before the Institution of Civil Engineers, on the application of electricity to the protection of life on railways. At that time there was only one single railway manager who supported me in the proposals I made. Every other railway manager violently opposed the introduction upon his railway of any system such as we have discussed here to-night. But, by dint of a little perseverance and persistency, I succeeded in inducing the manager of the London and South Western Railway to change his mind. He lived not very far from London, and several accidents had occurred on his line about that time, and he had ordered a bell to be fixed at his house, so that, in the event of another accident taking place, he was to be called up at whatever time it might be. That was just at the period when I had induced him to try the block-system. I met the same gentleman only a short time ago, and asked him if his bell was still in working order, and how many times it had been rung. He said he did not know whether the bell was in order or no, but it had never once been rung since the block-system was established. The only manager who supported the block-system in those days was Mr. Eborall, of the South Eastern Railway, and upon that line our old friend and past president, Mr. C. V. Walker, F.R.S., had established a system of

signalling by means of bells very similar in idea to that just described to us by Mr. Von Treuenfeld; and those who visit (and I hope all will visit) the Crystal Palace will find displayed on the counter, as a portion of the South Eastern Railway exhibit, a very interesting series of instruments illustrating the evolution of the block-system on the South Eastern Railway, under the guidance of Mr. Walker. As far back as 1850, every single level-crossing and every station was supplied with an electric bell to announce the approach of trains, and to do practically what we have seen can be done by the admirable system described to us to-night. But in England we have a body of censors who watch the doings of railway companies with a great deal of acumen; who hold a rod in pickle over every railway manager and over every railway engineer, electrical or mechanical; and who control the opening of a line, and insist on various points, one of which is, that in all systems of signalling by electricity there must be visual signals to attract the attention of the eye, as well as aural signals to attract the attention of the ear. Hence it is that in England no such system has been adopted as that explained to-night: in fact, in all cases the aural signals are accompanied by visual signals.

The safety of railway travelling is supposed to be improved but not secured by electrical apparatus—so much so that in this very room I was led once to remark that the only possible safe way of working a railway was to have one engine and one train, for if there were more than that, error was likely to arise from the complication of instruments dependent upon human will. But I was taken to task for that expression by Dr. Siemens, who humorously instanced the case, near Paris, where on a railway worked by a single train an accident had happened from the engine running into the tail of its own train upon the circular terminal. In the Siemens system, loud gongs attract the attention of linemen, who at times are supposed to be away from their huts and houses, occupied in gardening or other operations, and no doubt under such circumstances a church-bell arrangement is a good one; but such a contrivance is scarcely what is wanted in England, where the traffic is so great. We want not only a system of warnings, but a system by which those at stations

and gates, or in boxes, shall know that a train is coming towards them. We want a system that shall protect the line from one train being pursued by another; and we must also know that a train which has been signalled has arrived at the end of a section, so that the line is clear for any succeeding train. A simple system of gongs is quite impracticable for such purposes, and is not applicable except on railways passing through places such as the wilds of Ireland or the moors of Scotland. More elaborate systems are necessary where trains run with such frequency as in and near London. I have practically had little or no connection with railways for some years, and am, perhaps, getting rusty on the subject, but I was glad to hear what Mr. Spagnoletti said about uniformity in signals. I strove very hard at one time to bring about such an uniformity, but every railway company, while running its own trains on its own metals, also likes its own ideas to run in one groove, and the difficulty would be in getting any railway electrical engineer to adopt anything that was primarily adopted by somebody else on some other railway. The result has been that different systems exist on different railways, particularly in regard to visual signals. I have always maintained that, if there was one thing in which railway companies should be agreed, it is in establishing over the whole country one single signal that shall mean "all clear." How absurd it is to find on one railway that one ring of a bell means "clear," while on the next railway it means "blocked," while perhaps three rings of a bell mean "all clear;" on the next railway four rings mean "clear," while perhaps on another four rings mean "line blocked." One call which means "clear" in the south, means "blocked" in the north, and with a system of through trains such differences must lead to accidents. Had a proper block-system been worked, the recent Canonbury accident, and perhaps others near London, would not have happened. But with all the accidents that have happened, statistics show that probably the safest place in the world is a seat in first-class railway carriage. Seventeen thousand people are killed each year by accident, and of that number less than 50 passengers, on an average, are killed in railway accidents. More people are choked at their own dining-tables than

are killed on railways, and nearly twenty times as many people are killed through falling down stairs. The safety, or, rather, freedom from accident, in railway travelling is scarcely appreciated unless these strong facts are remembered. The enormity of railway accidents are expounded upon in the daily Press to a far greater extent than other kinds of accident; for if a lady's finger is smashed, by being where it ought not to be, when the railway carriage door is closed, a great fuss is made in the Press; while if an ordinary carriage accident happens, resulting in death, perhaps, it is recorded with perhaps a little sympathy, and nothing more is said. But if 540,000,000 of people travel each year with such a small percentage of accident and loss of life, the safety of such means of travelling is proved.

I would only remark on one other point, and that is, that in France, to my surprise, the railway people persist in the employment of the Morse recording system, and such like, when they must see that in England and in our Colonies that system which is specially adapted for railway working has proved itself to be the simple single needle. No telegraph instrument is more simple than the single needle, and less liable to get out of order. It employment is gaining ground in our Colonies and in South America, and the more it is known the more I am sure it will be liked; and we English telegraphists look upon it as our first and early love, and it has a special function in its applicability to railway working.

Mr. ALEXANDER SIEMENS: I have to a certain extent, of course, to anticipate Mr. Von Fischer Treuenfeld's reply, and I may also at once state that I have nothing to do with the railway signalling system, as far as inventing or improving goes. Mr. Spagnoletti, and to a certain extent Mr. Preece, talked about the Siemens system of signalling not being fitted for English railways. It has not been designed for that, and it has also been very distinctly stated in the paper that it was not meant to work on lines where trains are frequent. Mr. Spagnoletti also said that messages in full would be better than messages sent by signals as described, but that is partly provided for in the arrangement shown by Mr. Treuenfeld, for the keys can be worked by any man

or porter without difficulty, as the system is specially intended for railways where stations are few and far between, and where a quick message to the stations, if it only consists of a few words, is more important than a long message which would entail greater loss of time. Mr. Preece says that the Government in this country insist upon aural and visual signals as far as the blocking of the line is concerned, and therefore he says that the gong-system alone could not be used in England. We have another system which is a perfect block-system for such railways, but any explanation of that system this evening would have interfered with the paper on the gong-system, which is distinct. In our block-system the electrical and mechanical signals are interlocking—the signalman cannot give "line clear" unless he has the permission of the advance station; and when that permission is once given, and the line is once put "clear," he cannot give the permission back to allow another train to follow unless he has put his own signal again at danger, and such a system will fulfil all the conditions of perfect safety for lines of railway heavily worked with traffic. The advantage of the ink-recording instruments connected with the gong-system over the single needle is, that the stations get visual as well as aural signals about danger, and therefore in the hurry of an accident mistakes about what is wanted are not so likely to be made, seeing that the ink-recorder repeats the signal several times.

Professor W. E. AYRTON, F.R.S.: One point in Mr. Von Treuenfeld's paper which has special interest to me is the employment of a magneto-electric machine for signalling purposes. It has always appeared strange to me that these instruments are not much more used in ordinary telegraphy. Most telegraph engineers will remember the old form of magneto-electric instrument, such as the "thunder pump," as it was called, and Henley's magneto-electric telegraph, which were extremely inefficient, and therefore were very naturally abandoned. Some of my students have been making experiments recently as to what can be obtained with hand magneto-electric machines. With the machine they were trying they obtained, working a foot treadle, an electro-motive force of 700 volts with a bobbin having a resistance of about 1,000 ohms, going at 1,000 revolutions. From this it follows, since the

resistance of a bobbin of wire occupying a given space is proportional to the square of the number of convolutions of wire composing the bobbin, and the electro-motive force at the same speed proportional to the number of convolutions, that with a bobbin having a resistance of about 5 ohms we could easily obtain an electro-motive force of 50 volts. Now, this will send through 100 miles of telegraph line about 25 milliampères, which is eight times the ordinary working current. I think such results show that there is certainly a wide future for the use of such instruments for actual telegraphy, and especially for military telegraphy, where it is necessary to carry about the generator of electric currents. Members will remember the most interesting paper given a short time by Mr. Luke on telegraphs in Afghanistan, in which it was said that the Minotti form of battery was employed, and that it was the best portable form. But a 10-cell Minotti battery would give only about 10 volts, and, if 50 volts were necessary, the portability of the battery would be hampered by its increased weight.

Portable magneto-electric machines were specially made in India, by the late Mr. Schwendler, for detecting defective insulators out on the line. At first a commutator was attached to the machine, in order to send continuous currents through a galvanometer. However, after some time it dawned on us that we were all provided in our tongues with a fairly sensitive detecter of reverse currents, and the commutator was abandoned, and a "taster" substituted. It may be objected to the use of magneto-electric machines, that they are cumbersome, and to dynamos, that when small they cannot feed themselves. This latter result, however, only arises from the dimensions of such machines being usually wrong.

One use for such small dynamos suggested itself to me from what Mr. Spagnoletti said about the clockwork difficulty. I see no reason whatever why the clockwork in such a gong-signal arrangement should not be wound up by a small electric motor in the clock. Considerable power is required for a short time to ring a large bell, but Mr. Fischer von Treuenfeld has shown us that a small reversed current sent by a magneto-electric machine is quite sufficient to start the clock. Now, it occurred to me that a small continuous current sent by either a small magneto-electric

or dynamo machine would not start the bell, but, instead, would supply quite sufficient power to wind up the clock, the current being sent for a much longer period than the clockwork was required to run for—that is to say, dispense with winding of the clockwork by hand altogether, keep a small continuous current perpetually on the line to work the electro-motor winding up the clock, and send reverse currents for a short time by the magneto machine before us when the loud gong is required to strike.

Mr. Von Fischer Treuenfeld: Before replying to Mr. Preece and Mr. Spagnoletti, I would like to say that there are railways of great length, with few trains, and railways extending short distances, with many trains. Now, it is impossible to adapt a system of signalling apparatus which will answer the requirements of all those railways. Where there is a long line and only a single pair of rails passing over a number of roads, it is quite a different case to that of a very short line, say, near London, with many trains running at such short intervals as two minutes. The cases are so dissimilar that a system of signalling adapted for the former cannot reasonably be expected to be applicable to the latter. The apparatus before you this evening, as Mr. Alexander Siemens has said, has not been constructed for railways near London, neither is it stated in the paper that the instruments are recommended to do service on similar railways; but, as Mr. Preece said, there are cases, even in Great Britain, such as the wilds of Ireland and moors of Scotland, where gong-signals could be advantageously employed. That is exactly what I have said in the paper; but when you come to the consideration of Colonial railways, the circumstances become more identical with those of countries like Russia or the North of Germany, where gong-signals are employed. I beg to take exception to Mr. Spagnoletti and Mr. Preece in conveying the idea that Continental railways are not under the necessity of employing block-systems. It is not so! In two letters of mine recently published in *Engineering*, I alluded to the question of block-systems, and said that Continental railways had adopted block-systems in those places where heavy traffic and frequent trains passed over the lines. In such cases the block-system is employed, and in other cases where there is less traffic

the gong-system is used. I will now go further than this, and say that English railways have no block-system. English railways have systems of blocking electrically, *i.e.*, they have systems of conveying orders to the signalmen to do certain things, telling him to "block," etc., but whether he carries out the order or not is another thing; consequently, the so-called block-systems do not block, but only convey orders to do so. Allow me to say that Continental railways have block-systems, because the signalman cannot give "line clear" except he has permission to do so, and this is the forced absolute block.

I stated in my letters in *Engineering* that Messrs. Siemens have erected about 8,000, and it may be now 10,000, block apparatus on Continental railways, a figure which is large enough to prove that the block-system is greatly employed. By the Siemens block-system each signal box is in a forced dependence on its advanced and rear stations, and cannot give a "line clear" signal until it has permission to do so. I am very glad to see that English railway men—Messrs. Saxby & Farmer, Mr. Sykes, Mr. Spagnoletti, and others—have seen the necessity of the forced block, and are trying to introduce it. These few remarks will carry me over several questions, and I have already said that the gong-system is not intended for short heavily worked lines, and, if it is used in such cases, it is only as an auxiliary system. In reply to Mr. Spagnoletti's question as to the expense, I would say that many things have to be taken into calculation. Gates and level-crossings save the expense of building bridges, and, on long lines going through a thinly populated country, a telegraphist who understands the Morse or needle instruments would be too expensive an item at each crossing, and consequently something is required which can be attended to by any man who perhaps knows little more than how to use a pickaxe, and in such cases the gong answers the purpose, and is cheap.

Comparing instrument with instrument, the gong is necessarily more expensive than the single needle, but this is not where a comparison should be made, but, rather, that with the single needle a telegraphist is required, whereas with the gong an ordinary workman is sufficient.

The winding-up of the clockwork has never caused difficulty: it is arranged to go for two or three days, and the men are in the habit of winding it up when they get out of bed, and, should one morning be missed, the clockwork goes on till the next morning. All the questions as to the preference of the block-system in England I quite agree with, but they do not touch upon the paper, and I beg to be excused for having also touched upon the block-system, because I think I am out of order in not adhering to the subject matter of the evening's paper.

Mr. Preece somewhat complained that recording instruments took preference to the single needle on the Continent. The reason for that is, that in countries like Germany, Russia, and France, people are very much inclined to discipline, and if anything goes wrong they like to find out who has done it, which could not be done if the single needle were employed; and for that reason it would seem that that instrument will not be employed to any extent on the Continent, at any rate in the countries I have named. Mr. Spagnoletti said that the principal object of railway signalling is to ensure the safety of the traffic. I agree, and can only say that this is exactly what the gong-system is made for.

The PRESIDENT: Gentlemen,—If we were to discuss the difference between the use of needle instruments and printers, and between block-systems and the system which has been described to us to-night in such an interesting way by Mr. Von Treuenfeld, we should probably be here till to-morrow morning. Mr. Von Treuenfeld will consider, I am sure, that in touching upon other points, Mr. Spagnoletti and Mr. Preece did not wish in any way to criticise the admirable paper he has given us, which was rather a means of communication with gatekeepers, partly acoustic, than a system of communication between signalmen and engine-drivers; and I think there is very great difference between the two. Circumstances under which such a system can be used in the Colonies can be very clearly understood. In the Colonies, in the East of Europe, and in such countries where the railways are not very well fenced, a system of the kind would be most useful. The gates at level-crossings in such countries are not used in exactly the same way that we use them. Gates thus situated here, when "closed," are

closed to the public; the expression used by Mr. Von Treuenfeld means "closed to the train"—in fact, the term used is exactly the opposite to the way in which it is used in this country. You can perfectly well understand why the men in charge of the level-crossing would leave the gates closed to the train during the long intervals between them, namely, that the country people on the road should not have to open and shut the gates, whereas here, for just the opposite reason, our gates are closed to the road, and not to the train.

As regards the gongs, I do not propose to make any remarks, but there is one position in which I think they might be used in this country, viz., at dangerous places, for the purpose of replacing fog-signals, when it is necessary to convey signals to engine-drivers during times when the atmosphere is obscured.

There is no doubt that you will all join me in giving a vote of thanks to Mr. Von Treuenfeld for his paper. It is so late that I will not ask to have it proposed and seconded in the ordinary way; instead, will you allow me to call upon you to vote with acclamation a vote of thanks to the lecturer for the way in which he has brought this most interesting subject before us this evening—so accurately that, when our Journal containing the paper is published, our Colonial friends will be made aware that there are other systems suitable to their countries and suitable to districts sparsely populated, where trains are unfrequent, which they may use, and which are more or less different to the systems sent out to them from England. I ask you to join me in the vote of thanks to Mr. Von Treuenfeld.

The next meeting of the Society will be held on March 9th, when a paper by Drs. W. H. Stone and W. G. Kilner will be read, "On Measurement in the Medical Application of Electricity." I feel sure that we shall have a crowded audience that evening, for it will be the first occasion on which electricity medically applied has been brought before the Society.

The meeting then adjourned.

The One Hundred and Ninth Ordinary General Meeting of the Society was held on Thursday evening, March 9th, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the previous meeting were read and confirmed; the names of new candidates read out and ordered to be suspended; and it was announced that the Council had transferred from the class of Students to that of Associates,

Mr. J. D. F. ANDREWS.

The SECRETARY then reported that since the last meeting donations to the Library had been made by Professor Zetzsche, by Mr. G. M. Beard, and that the Russian Government had sent a copy of their report on telegraphs for the year 1881. It was stated that Professor Zetzsche's donation consisted of eight papers, which the Librarian had reported to be very valuable on account of their scarcity.

The following paper was then read:—

ON MEASUREMENT IN THE MEDICAL APPLICATION OF ELECTRICITY.

By W. H. STONE, M.A., Oxon, F.R.C.P., and W. J. KILNER, B.A., M.B., Cantab.

Dr. STONE: Mr. Chairman and gentlemen,—It was at your suggestion that we undertook a somewhat difficult task—a task, moreover, of which only part can be efficiently fulfilled within the time at our disposal. We must therefore ask you, Sir, and the members, to consider this as a preliminary paper intended to clear the ground, with the view, if you wish it, that we should at a future period enter into further details.

The subject of medical electricity, you will probably agree with us, is one that requires a vast deal of forethought, for in many departments it is but a heterogeneous mixture of loose statements, doubtful opinions, and erroneous therapeutics. I took up in the present week a very highly reputable electrical periodical, and in

it I found (I will not give the name of the writer nor that of the large hospital from which it claims to emanate) the following passage :—" As the originator of magnetic appliances in the year 1865, and having had extensive experience in their use for nearly twenty years, I feel in a position to express an opinion as to the true remedial value of magnetism. When these appliances are properly constructed and applied, and suitable cases are selected, magnetism, like other electrical qualities, will be found to have its special sphere of usefulness in a given class of ailments. The therapeutical value of all electrical qualities is based on their physiological actions; hence we have in electro-medical practice three orthodox electrical qualities, viz., galvanism, Faradism, or induced electricity, and Franklinism, or static electricity; the first exerting a special action on nerve tissue, the second on muscular tissue, and the third acts similarly, though more violently, than the second. Yet another electrical quality may be added, viz., magnetism, which, though not at present orthodox, is none the less valuable, its special function consisting in an action upon the circulating fluids of the body; and from the facility with which the lines of magnetic force may be caused to pass through glandular structures, congested and debilitated conditions of such organs, viz., the lungs, liver, kidneys, etc., prove just the cases in which magnetism proves most serviceable."

Now, setting aside grammatical errors in this extract, I have no hesitation in saying that every sentence contains a gross scientific fallacy which modern science does not bear out, yet such errors appear to be believed in and supported by the public, for in another publication occurs an advertisement to the effect that you can have the curative powers of electricity or magnetism made use of for a horse or a cow for the sum of 5s., for the human subject for the sum of 2s. 6d. In the case of a sheep the tariff comes down to the small sum of 1s., and no doubt for domestic animals, such as a cat, the fee would be as low as 6d. for each electrification.

Now, with things in such a condition, it is a bold and perhaps dangerous undertaking to attempt to begin with what I hope will agree with your ideas on the subject, and which therefore I have put down at the head of my paper, namely, "Measurement." It is

impossible this evening adequately to deal with hysteria and metallotherapy with magnetic appliances: we are in far too elementary a condition as regards electricity to see through these obscure phenomena at present. That there is some reality in the phenomena I do not doubt, but whether they are properly understood and interpreted is entirely another matter. Probably the key to the enigma of the relation between electricity and nerve-force is yet to be found. At present the statement that "electricity is life" is demonstrably premature, if not erroneous. Speaking, however, generally, medical electricity has to a great extent suffered from its exclusive handling by physiologists: I may add, with the permission of my colleague, perhaps a little from its being handled by physicians. There are in the English language three words all derived from the same root, each possessing a different meaning. Two have been accepted; the third we need to introduce: we wish not so much the physiologist or the physician as the physicist. We beg respectfully to put the matter to this young, active, and vigorous Society. You can be of very great service to us physicians and physiologists by giving us suggestions, especially in the department with which you are no doubt most conversant (more conversant than we are), viz., the department of measurement. Medicine and its kindred departments lend themselves extremely ill to measurement. The tone of mind required in the physician is not that of the mathematician—it is rather judicial than computative. It is often a question of weighing doubtful evidence and of balancing alternatives rather than of solving an equation. But in electricity we have to solve equations, and, until we begin by settling the fundamental units, the whole department must remain in the condition to which I have adverted. Men who work by measurement are generally sterling and accurate men. The admirable remarks recently made by Professor Schuster at Owens College, on the use of mathematics in science, are distinctly to the point in what I am venturing on to-day. Where measurement can be used it should be used, and this is the text on which I propose to speak for a few brief minutes. The subject was taken up at one of the meetings of the Congress at Paris, and I will refer to that shortly, but before so doing

I will give you a general résumé of medical electricity. It appears to be used in three forms, or four, but I prefer limiting it to three, because the fourth, perhaps, is not of very great importance. 1. We have the continuous current. 2. The continuous current may be made to intermit and so produce a certain amount of chemical as well as stimulant action. 3. And we have for a long time used the induced currents which are now called "Faradic," and, on the Continent, faradisation. Besides these, static electricity had great vogue some thirty or forty years ago, and it was then thought that a great future was before it as regards its curative powers. Up to now that idea has not been realised; and, although there are individual observers worthy of credence who think they derive real results from it, as a rule medical men will agree, that if a current of high tension is desired for application, it can be far better obtained from some sort of coil than from a frictional machine. The reason, however, that "faradisation" first obtained such vogue undoubtedly was because it was the first invented, and that it was cried up, worked out, and made a great deal of by a very able, genuine, and learned man—I mean Duchenne. His work on localised electrisation drew early attention to this department. He was able to point out a definite principle of diagnosis of disease possible by means of these high tension currents. He isolated a number of pathological states by means of the induction coil. All his work, so far as he went, has been found extremely good, and has been a great advance in the subject, but it represents only one side, and that suited to the conservatism which is not uncommon in every profession besides the medical. Physiology, moreover, has utilised in the stimulation of the induced current a very convenient means of testing the irritability of nerves and the contraction of muscle. Even in vegetable physiology, experiments have recently shown that currents take place; and in the localisation of the functions of different parts of the brain, by far the most convenient stimulant is a current passing between two points. I cannot help feeling myself that muscular contraction has been hitherto rather too much insisted upon, so that it has obtained excessive prominence as a therapeutic agent. To show that this is not simply a view of

my own, I will quote a few words from one of the most genuine works which has appeared, *i.e.*, the great Cyclopædia of Medicine of Ziemssen, vol. xiii., in which it is said by Professor Erb (one of the most able men in this department) that " both kinds of current are effective in the cure of paralysis. . . . No other remedy has within a recent period gained so much ground as electricity in the treatment of spinal disease. But few can be compared with it for activity. At first, great obstacles stood in the way of its general acceptance,—these are now overcome ; no one now doubts the possibility of reaching the spinal chord with the electric current, and the unanimous experience of electro-therapeutists no longer allows us the right to doubt that electricity has accomplished many, in some cases remarkable, cures in disease of the chord, and that it has essentially improved the hopeless prognosis of many spinal diseases."

This extract says nothing about the continuous current which is made to intermit, and this possibly is to a certain extent novel. There are certain appliances here by which I shall be able to show you that, by causing more or less rapid intermissions of a continuous current, you can, as it were, steer between the two—you can produce stimulation with chemical action, which I take to be the great agency involved in the continuous current, and I hope that this will reconcile, as it were, the hostility between the two forms. But before we can proceed one single step in this path, we must have a tolerably accurate mode of measuring the agent we are employing, and this has hitherto been singularly neglected, or conducted on a comparatively unscientific basis. It is perfectly obvious that the units we employ should be as far as possible those commonly used in the scientific world, viz., the ohm, the volt, and the weber (or ampère, which I believe is the present name for what was formerly called the weber). I shall devote a few words to each of these, and first to resistance. The resistance of the human body is singularly and inexplicably great. I do not think that it has quite penetrated the minds of persons who apply electricity to the living body, how great its resistance is. From hand to hand in the human body, the resistance is 6,000 ohms. In the larger bulk of the trunk of the body it is less consider-

able, though it never sinks below 1,500 ohms, even when the current is passed from the nape of the neck to the base of the spinal cord. The resistance of the head from the nape of the neck to the forehead is also large. In one experiment it appeared as 1,930 ohms, and in another case 2,500 ohms, with the skin properly wetted. In all these cases the resistance can be run up to any figure if the skin be dry, and therefore the skin should be wetted first, and the poles also wetted, with some conducting solution—perhaps, best of all, solution of common salt. Sulphate of zinc solution has been used for wetting the skin in experiments of this kind, but it destroys the skin and causes a disagreeable feeling after application.

As regards the resistance of the different tissues, we have some good experiments by Professor Eckhard. Muscle is by far the best conductor in the body, and Professor Eckhard has put that down as 1; then, comparatively, cartilage is 2; the tendons and nerves are a little more,—here being a very strong argument against the agent which permeates the nerve trunks being actual electricity, though it may be some modification of it,—and the resistance of bone is 19. Mattencci makes some remarks on this point, and says that the muscles conduct four times as well as nerves, and that there is very little difference between the conductivity of the the nerves and that of the brain and the spinal cord. The resistance of the skin varies from day to day—it is modified by moisture and fulness of the capillaries. On one occasion, when experiment was made, the positive pole was placed on the sacrum of a child, while the negative pole was placed on the extensors of the foot, with a small current of known power applied. It was found that the resistance of that part of the body was 11,250 ohms. After soaking the skin well and applying the current for some time, the resistance sank to 2,875. Three days previously, the resistance, on being tried, was above 13,000 ohms on a very dry day; and 3,000 ohms in same patient on a moist day. Personal idiosyncrasy seems to cause a difference in the body. A damp skin, for instance, is more readily traversed by a current than a dry one. In the same person the skin on different parts does not conduct always to the same extent. The soles of the feet and palms

of the hands offer the greatest resistance, and the base of the neck the least. With the exception of the face, any part of the skin habitually exposed to the weather has its resistance augmented. Disease causes a very considerable difference in resistance. The skin over the affected muscles, in lead paralysis, has its resistance largely increased, while in many old cases of hemiplegia it is decreased to a greater or less extent as atrophy has taken place.

At present we are hardly in a position to say for certain how muscular resistance may vary in health; but in disease it can be fairly stated that it sometimes diminishes and sometimes augments. The augmentation takes place at the commencement of degenerative changes, which are caused by the interior conduction of the fat, which replaces the muscular tissue; later on, when the changes have still further advanced, and the fat has been more or less completely absorbed, the resistance increases. In an early case of infantile paralysis, for instance, the sound leg had a resistance of 3,482 ohms, and the paralysed leg a resistance of 3,127 ohms. In another case, further advanced, the sound leg resisted to the extent of 2,500 ohms, and the affected one to the extent of 3,250 ohms. A number of such figures constitute a very fair means of obtaining a scientific basis.

Then as to the question of the current which may pass through the human body with impunity, and which can be safely used. Here we have very discordant results. There have been at least three deaths from the passage of a strong current: one which took place in a music hall, near Birmingham, another in the Russian navy, and another one at Hatfield. As to the first, I have not been able to obtain any trustworthy details of symptoms. The man in the first case lived fifty or sixty minutes, which of course excludes any possibility of the current which he received being anything like a stroke of lightning, or causing sudden syncope; but in the second case the death seems to have been almost instantaneous. With these very strong currents I do not propose to deal, but in ordinary medical practice it may be approximately stated what current can be borne with impunity over different parts of the body. I have a case now in hospital which apparently shows the greatest indifference to the strongest

current that has been yet tried. The patient was able to bear fifty milliwebers. My galvanometer shows milliwebers, and should be replaced by milli-ampères. A current of fifty milliwebers was borne with difficulty, but the patient takes twenty milliwebers daily with great advantage. His complaint is locomotor ataxy.

In a diabetic case in which I succeeded in modifying the malady (and which I referred to in a paper before the British Association last autumn), I obtained information quite accidentally. The patient was an instrument-maker, and was extremely enamoured of the current, but unfortunately carried it too far. He used, without my leave, sometimes to take the current from as many as 25 of these powerful bichromate cells (such as are before you), and I would not say that his ultimate death may not perhaps have been accelerated by the unlicensed excessive use of the current. However, 50 milliwebers can be borne, and 20 milliwebers can be taken easily. The diabetes case was treated by applying the current to the head, where an excess of current would of course be most dangerous. The bichromate cells used have an electro-motive force of 1·8 volts. Their resistance is somewhat large.

As regards continuous current, it matters very little what battery is employed: Leclanché's, bichromates, and zinc-carbons with sulphate of mercury, all act well. A very simple form of battery is made with the ordinary electric light carbons and a rod of zinc dipping in mercury. Such an arrangement can be put together very compactly, will give very little trouble, will do no harm when thrown out of action, and is always ready for use. [A battery of this latter description was explained in detail.] Dr. Onimus, whose recent work I have here (and who is one of the best writers on this subject), lays very great stress upon two points with regard to batteries used for the continuous current, viz., first, that they should have very feeble chemical action, and, secondly, should have great constancy. As regards the second point, everybody will agree; but the question of chemical action can so easily be settled by introducing resistance, that it seems hardly worth while to make such a point of it as he does. We have wanted for a long time some easy method of measuring continuous currents. As in-

struments have been for a considerable time before the public which enables a nurse or attendant to manage the current. It is a galvanometer divided into milliwebers, but Mr. Kilner has produced a more accurate instrument, which we have here.

You will see that the object is to obtain a portable, handy, and convenient means of measuring the current. The subject was mentioned before the International Electrical Congress, at Paris, but the reference was very brief, and I may perhaps be allowed to say not altogether satisfactory, for the Congress passed on immediately to physiological experiments.

As to the resistance of the poles, a good deal of learning has been expended, unnecessarily perhaps, upon the kind most advisable to use; but one thing is clear, that the poles should be very large. The poles usually made are not large enough by one quarter; they should be four or five times the present usual size. The Congress made some good recommendations on this point. It advised the use of either amalgamated zinc with a neutral solution of sulphate of zinc, or sculptor's clay worked up with a solution of chloride of sodium, a little less than one per cent. in water. This solution, introduced by Mr. Gallagher, has been called the physiological solution, and it preserves this name in Germany. What we find most practical is powdered carbon covered with wetted lint or some sort of woollen tissue moistened with a saline solution, such as what is called "spongio piline," a tinned wire being run through the whole and a large surface thus obtained.

I have next to speak of the continuous current made intermittent. Here, of course, the measurements are not more difficult than they were. I have an instrument which possibly may not have been seen in this room before, which I will ask you to more closely examine when the meeting adjourns. By this instrument I can make a current from my bichromate cells intermittent, and vary the period of intermission at will. It depends upon the old principle of the metronome for making contact. One contact can be taken for each double vibration, if desired, or if a small piece of thick wire be taken out two contacts are made. The period of vibration being varied by shortening or lengthening the pendulum,

the speed of the intermission can be regulated, the operator always also having the power of doubling the number of currents. The apparatus is furnished with a small condenser, since the break of a continuous current of any power is somewhat painful, and the patients complain of it. [The construction of the instrument used for this purpose was described in detail.] You will see that the object of the condenser is to take away the effect of the extra current, and this, combined with the vibrating instrument, renders the whole arrangement a very superior one.

I have next to speak of the induced current, and here we are in a great difficulty. It is very difficult to obtain a fair measurement of induced currents, and the report of the recent Commission on the subject is a little unsatisfactory in this particular. They did not consider it necessary in therapeutics to make any arrangement for the measurement of the induced current other than that obtained by the ordinary sledge apparatus, providing a certain pattern of instrument is conformed to (as is done in Germany), and the same strength of current used, viz., one Daniell element.

No doubt, for therapeutical purposes, a great variation of current can always be obtained in the instrument of M. Kruber, of Berlin, but that is not measuring it. Here is such an instrument, with a chronometric interrupter, which works in the primary coil. It makes no noise, and works well with two Leclanché cells. The three secondary coils vary from a resistance of less than one ohm to that of a fine wire, the resistance of which runs up to 1,900 ohms. A very great desideratum remaining is the power of accurate measurement, the present form being only arbitrary. The induced current, moreover, being of course alternate, and at the make and break in two directions, the breaking current very much stronger than the making current, introduces another difficulty. The strength of this breaking current can be, to a great extent, got rid of by means of the condenser I have spoken of. But it seems to me that, if any accurate measurement is to be arrived at, one or other of the contrivances I now proceed to speak of must be adopted. The first that occurred to me was to use a shunt for the induced current, a vacuum tube in which I could vary the resistance, and a curious result came from this. I have the

arrangement here, and propose to show it. [The mercury vacuum tube was described, and a more or less perfect vacuum produced, through which the current was passed.] The current is completely or partially shunted by raising or lowering the mercury, and we have the power of sending more or less current through the patient. This gives an approximative measurement. Latterly it has struck me that a better plan would be to make use of condensers, and I have made a good many (as you see by those before you) for the purpose, and I find that they answer extremely well. I charge these condensers and discharge them through the patient. For the latter purpose, a similar arrangement to that used by Planté in some of his experiments, and of which a model is before you, was adopted.

Two pairs of binding screws, three on either side, lead to corresponding springs bearing on a cylindrical piece of ebonite, on which are fixed four bars of brass at right angles, two towards one end and two towards the other. The first two connect the battery with the condenser, and charge it; then a quarter turn is given to the cylinder, and the other two discharge the condenser into the two terminals which carry insulated wires to the patient. In that way, if desired, a condenser of known capacity, the potential of which is obtained without much difficulty, can be arranged to give discharges of a force approximating to that considered requisite to be applied. I have made these condensers of various forms. Here is one made of mica, which has great inductive power; here one of smaller capacity, embedded in paraffin; and here is one for strong currents, made of thin plates of ebonite immersed in ordinary paraffin oil, which is a good insulator, and which prevents leakage. All the condensers are shunted by a small copper rod, which can be removed when the condenser is required for use. We have since tried another plan, but it is hardly in condition to bring before the Society just yet, although it promises to be successful. It depends on measuring spark length and on introducing a very large resistance. A very large resistance would to an extent act like a condenser. We may thus in the end be able to devise a more trustworthy and accurate method for the interrupted, as we have already for the

continuous current. It is especially as to the measurement of induced currents that my colleague and I so much wish to profit by the opinions of the members of this Society. They can help us very materially if they will give us suggestions as to more perfect methods of measuring an induced current, remembering that it must not be a very powerful one, but something to be tolerated by a person in a feeble state of health.

Letter received subsequently from Professor H. McLeod.

COOPER'S HILL, STAINES,
March 10*th*, 1822.

This morning I determined the resistance of my assistant, a boy of about 19. Into two beakers a 1 per cent. solution of sulphate of zinc was placed. Two large zinc plates were used, and when both were dipped into the same beaker the resistance measured by the Wheatstone's bridge was 20 ohms. A plate was then put into each beaker, and the boy dipped his middle fingers into the beakers to the depth of the first joint: resistance 28,380. The fingers were then placed in as far as the second joints: resistance 20,380. Then the fore and middle fingers to the second joints, 11,880. He then placed all his fingers in, 7,780. Then the hand to second joint of thumb, 5,580. Then as far as the wrist, 3,980; and, lastly, the whole hand to three inches above the wrist, 3,550. Unfortunately, the beakers were not large enough for a further immersion, but obviously we had come nearly to the limit, as a large increase of surface of contact had made a comparatively small alteration in the resistance.

HERBERT McLEOD.

The PRESIDENT: I think that the meeting will very be glad to hear any remarks that Dr. Kilner may wish to add to the lecture which we have just heard from Dr. Stone.

Dr. W. J. KILNER: This galvanometer, which I have used for three years, has a vertical needle with a mirror attached, and its coils have a resistance of exactly 1,000 ohms. It is graduated so that every division on the scale corresponds to a definite strength of current. I find that the least current I can make use of for the

variations of the human body is 25 microampères. That would allow a deflection of 40 divisions of the scale for 1,000 microampères, and a volt passing through the galvanometer would equal 40 divisions, so the scale can be easily graduated. When the scale is graduated in this manner, it is only necessary to add several shunts to it. Instead of taking the numbers in decimals, I have tried to keep the figures down as low as possible, so that in applying a current to the human subject the smallest variation in each individual case can be ascertained. In the instrument before you, each division of the scale, according to the shunt used, represents 25, 50, 100, 150, 200, 300 microampères, and, as there are 100 divisions, it will register from 25 to 30,000 microampères. I have added also a small water regulator with a copper solution, so as to avoid as much as possible polarisation, and by its aid any current I wish to apply to the body can be quickly done. Also I find with this galvanometer, with the addition of a set of resistance-coils, I can test the resistance of the body with great ease. It must be remembered that all these operations ought to be done quickly, or else fallacies are introduced, as the current in passing through the body causes perpetual changes, especially in disease, and the resistance offered to the current varies from moment to moment. It might be better to have a still more delicate instrument, but this is as accurate a one as I can work.

As regards the electrodes, the larger, as a rule, for general administration, are the best; but when it is required to select any particular muscle, smaller ones must be employed. I have here both large and small sponge-holders, which can be fixed to the handles attached to the galvanometer, and immediately changed at pleasure. There are also carbon electrodes.

The PRESIDENT: When you speak of resistance, do you refer to the whole resistance of the body, or of individual limbs?

Dr. KILNER: To measure a healthy limb in comparison with an unhealthy one, you place one pole upon some part of the body in the middle line, and then you place the other pole first over the healthy, afterwards over the unhealthy part. The measurement of the current must be made quickly, because, especially in disease, the changes take place with great rapidity. After measuring the

current, if the body be replaced by a known resistance and the strength of the current again ascertained, the resistance of the body can be calculated with sufficient accuracy to show that there are great differences in the various diseases.

Mr. W. H. PREECE, F.R.S.: The Society is to be very much congratulated in having had to-night such an excellent discourse on a new subject from its member Dr. Stone. I think it may be acknowledged by all, that when in the practical application of any science the appliers themselves have reached the stage of quantitative measurement, they have made very great progress indeed. It was only when the British Association took up the subject of electrical measurement that telegraphy itself can be said to have really made a start forward; and when we now find that the medical profession have taken unto themselves those mysterious symbols of ohms, volts, farads, ampères, and others, we certainly may hope that in a very short time we shall hear of very rapid progress. We all thank Dr. Stone very much for giving us a promise of favours to come in future papers.

Curiously enough it was only yesterday morning that I received from a young friend in Cornwall a refutation of that very strange statement which Dr. Stone read from somebody who wrote in the *Electrical Review*, and who took to himself the credit of being the originator of the application of magnetism or electricity, whichever he meant, to therapeutic purposes. He took credit to himself for having started this in the year 1865, but my friend sent me a copy of a book that was published in the year 1759, by no less an author than John Wesley, and this book, the original book of John Wesley, is to be found in our admirable library, the Ronalds collection. Its title is "The Desideratum; or, Electricity made plain and useful by a lover of mankind and common-sense, the Rev. John Wesley. 1759." Now it is a very remarkable fact that the first practical application of electricity to any useful purpose was that by Franklin, not long before the date of this book, and the second practical application of electricity to useful purposes was its application to the cure of disease; and, therefore, if age gives the subject which Dr. Stone has brought before us to-night the right to be brought before this Society, certainly the subject

which he has brought before us is more entitled to our consideration than telegraphy itself. I was glad to hear Dr. Stone make a few remarks about that quackery which appears in the advertisement columns of our daily Press, throwing electricity before the face of every one, where we see not only, as he said, "Electricity is life," but where we find certain powers supposed to be applied to hair-brushes, and even to tooth-brushes. There is a certain Dr. Scott who is constantly thrusting down the throats of the British public that he has produced a tooth-brush which, by electric agency, succeeds in curing toothache. This Society will certainly to an extent fulfil its mission if it can put down such ridiculous nonsense.

One point upon which I would ask for a little information, either from Dr. Stone or his colleague, is this:—Those of you (and there are many in this room) who are in the habit of playing with electricity, whenever a shock is received from any instrument or from any cause, find this, that according to the strength of current, so does the locality where the shock is received vary. For instance, if you touch a wire from which weak currents are flowing, you will find a tingling sensation at the tip of your fingers; if you take a stronger current, you will find it extend to your first joint; a stronger current will go to the next joint; a good strong shock will go to your wrist; and if you take a good electrostatic discharge it will go to your elbow; and if any of you have been so unfortunate, as I have, to take up carelessly a Leyden jar during a lecture, you will find that you will get a tremendous shock in your chest. Now there seems to be some reason why the position of these sensations should vary with the strength of the current that passes through the body, and if our friends the doctors are not able to answer that question to-night, I venture to offer it to them as something to be investigated.

Dr. Stone asked for some suggestions from those present to enable him to measure induced currents, or rather, perhaps I should say, to measure alternate currents. Now those who were present in Paris and saw that splendid Exposition had probably the opportunity of seeing a very beautiful device by Dr. Werner Siemens, to record the currents induced in telephones. Dr. Werner Siemens had an electro-dynamometer fitted with a mirror, and he

was able to throw a spot of light on to a screen. Now in an electro-dynamometer the effects perceived are simply dependent upon the repulsion between two currents flowing in opposite directions. They do not depend at all upon the absolute direction of the current, but upon the simple fact that if you have two wires the currents in those two wires must be in opposite directions to obtain repulsion. The result is that in an electro-dynamometer, whether the currents be continuous, or whether they be alternate, you always get a deflection in the same direction, and so an electro-dynamometer gives you an opportunity of measuring the strength of alternate currents. A very interesting experiment on that occasion was shown to a small audience, who were under the guidance at the time of Dr. Werner Siemens, by Professor Hughes. Professor Hughes saw at once how the action of the electro-dynamometer came about, and the idea struck him, that if he caught the dominant note of the disc of a telephone, he could produce a stronger current than Dr. Werner Siemens. So he took a telephone, and said something to this effect: "I think I can make that spot of light go off the scale if I mention the name of Faraday." So he mentioned various names: "Siemens," —the spot remained quiet; "Helmholtz,"—the spot remained quiet; "Adams!"—a little movement of the spot; "Faraday!!" and off the spot went like a shot, because the word "Faraday" was pronounced in the dominant note of the disc of the telephone, and the consequence was that the disc of the telephone made greater vibrations when under that note than any other, and we were at first all surprised to see the spot of light respond to the name of Faraday. One thing pleased me, and I am sure will please every telegraph engineer present, and that is to find how ready with his hands Dr. Stone has been, and how apt with his tongue in bringing before us terms and matters with which we are familiar; and I am sure every member of the Society must feel this, that when the experience of its members is carried from one path to another, the Society itself is discharging its very highest function. It enables the experience gained in one sphere of knowledge to be applied in other spheres of knowledge; and I am certain of this, that Dr. Stone has only to apply, or to ask any

single member of this Society here present, either for the loan of apparatus, or for the loan of knowledge, and, like myself, every man will cheerfully place his knowledge, his experience, and his laboratory at his service.

Mr. WALTER H. COFFIN: I would support Mr. Preece's remarks as to the antiquity of the medicinal aspect of magnetism, which is as old as the history of human ailments. One of the earliest Chinese formularies prescribes pulverised loadstone with brown viper's flesh, and other equally efficacious remedies. Doubtless the occult properties attributed to the magnet of a *soul*, or *anima*, were by the earliest writers regarded as curative charms; and the obvious correlation of the equally mysterious force of electricity must have suggested its medical application from the first time its simplest phenomena were studied. I feel, Sir, that the chief interest of Dr. Stone's communication is the great suggestiveness of his attempts to get a standard value of measurement for induced Faradic currents, in which respect the medical application of electricity has been greatly at fault. We have galvanometric means of knowing exactly what we are doing with constant currents; and I would remark that there is an excellent little vertical galvanometer made in London, divided into milliwebers, which is extremely convenient, and comparatively constant, and which obviates the inconveniences of that of Sprague of Birmingham, and Gaiffe of Paris, whose instruments are better known. Being calibrated empirically in microampères, it enables the surgeon administering a current to know precisely what he is doing, regardless of varying resistance and electro-motive force; and not only to record and compare his observations with accuracy, but to direct a dose or course of treatment more definitely than the usual instructions, "Oh, give a current of so many cells," than which anything more vague and unsatisfactory could hardly be imagined. I hope Dr. Stone will at some future time give us the outcome of his experiments in measuring the induced current. I have sometimes felt that it might be connected dynamically with a mechanical effect.

Had I been aware that the paper to-night would cover so wide a field, I would have brought forward a few little appliances that

might have interested Dr. Stone and others. I have employed the small Bréguet interrupter of the induction apparatus to chronometrically interrupt the voltaic continuous current. The metronome is a good and convenient means to that end, and an instrument that would be naturally suggested to so accomplished a musician as Dr. Stone.

The attention of makers of constant-current apparatus may with advantage be drawn to the importance of constructing their batteries so as to avoid the many opportunities that now exist for the accidental and wholly unnecessary infliction of the voltaic shock in regulating appliances. Both current collectors and rheostats may be so made as to entirely prevent either breaking contact or short-circuiting the cells.

I can distinctly endorse Dr. Stone's statement as to the importance of large polar surface of electrodes or rheophores in applying the current, and have gone so far in this direction, when convenient, as to employ the old method of immersion of an extremity in water with great advantage. When possible to entirely immerse the body in a bath, the water may very conveniently be used as a shunt to almost automatically and with great delicacy regulate the intensity of the current to the sensations of the patient.

Prof. H. McLeod: I would just remark that the resistance of the human body, as measured in the way mentioned by Dr. Stone, surely depends very much on the size of the electrodes, as it would in the case of an ordinary telegraph earth-plate. It would be well if the size of the surface of the electrode applied to the body were stated when the resistance of the body is spoken of as so many ohms. Really the resistance, I should imagine, is principally the resistance of the skin at the point at which the electrode is applied, and not so much the actual resistance of the cross-section of the body through which the current is passed.

Dr. Lobb thanked Dr. Stone for reintroducing the subject of medical electricity, but regretted the absence of English names among the historical references. With the exception of Faraday, no other English name had been mentioned; while among early English investigators in the subject might be mentioned (as Mr. Preece had done) Wesley, Cruickshank, Smee, Dr. Lawrance,

and the speaker himself, who had devoted, he said, twenty-seven years of his life to the study of medical electricity. In a paper published by him in 1866, entitled, "An attempt to adapt the laws of dynamics to the science of medical electricity," and in which he had been assisted by Mr. Desmond FitzGerald, it was stated, as the result of experiment, that the resistance of the human body was 10,000 units. Wheatstone's bridge and Ohm's law were employed in the measurements. He said that Mr. Pulvermacher had rendered valuable aid to medical electricians by his admirable apparatus, and he repudiated the idea of the Ramon carbon electrodes or poles, and said that a brass knob surrounded with sponge wetted with plain water was a sufficient conductor for all purposes, and he agreed with Dr. Coffin's plan of immersing the limb in water. Duchenne's plan was used for localising electricity in certain muscles and nerves, but special conductors, and not large ones, were required for applying electricity to the sensitive organs, while for general purposes large surface poles were decidedly the most valuable. No doubt, in studying medical electricity, general electricians could aid the medical profession by the loan of apparatus, such as galvanometers, and various apparatus of the sort adapted for measuring purposes.

Mr. R. K. Gray asked Dr. Stone what he had found the resistance of the skin to be. In using large surfaces for applying the current, a greater section of the skin would be brought into play, and would show whether the skins themselves had a higher resistance than any of the muscles.

Mr. Desmond FitzGerald thought it was a mistake to attach much importance to the internal resistance of the cells employed for medical purposes, seeing the very high resistance of the human body through portions of which currents were sent. It was far more important that the electro-motive force should be constant; and the fact of the depolarisation effected by air was an advantage frequently lost sight of. Electrical engineers would do well for their own instruction to make experiments as to the depolarising action of the air. Mr. Preece had rather anticipated him in commenting upon the method of measuring alternate currents, a point not referred to by Dr. Stone. The electro-dynamometer was be

ginning to be well known, and was perhaps the only instrument well adapted for the measurement of alternate currents. The voltameter, also, had not been mentioned, although in the case of the continuous current it could advantageously be employed. The electrical resistance of a limb could hardly be given with any accuracy in ohms, for two reasons, viz., because a great deal depended upon the size of the electrodes, and because one of these only could be perpendicular to the axis of conduction, since it was generally impossible to disconnect a limb for the purpose of testing.

Mr. W. P. GRANVILLE asked whether in Dr. Stone's opinion the variation in resistance of the body, when diseased, was not caused by the effect of the disease upon the skin; as it offered by far the greatest amount of the resistance of the whole body. The figures quoted by Dr. Kilner showed that the internal part of the body could not have a resistance of more than one-quarter of the skin surface, and therefore it seemed probable that the principal effect of a current passing would be upon the skin, and the variation of resistance of the body produced by the passage of a current would be a variation produced in the state of the skin, and probably that alone.

Mr. C. E. SPAGNOLETTI had been interested in the subject of medical electricity for many years, but, not being a medical man, his experiments had been made within very narrow lines indeed, compared to those open to the medical practitioner. He produced a book written by James Ferguson, F.R.S., dated 1770, in which an excellent account appeared, accompanied with diagrams, tables of results, and particulars, of most wonderful cures consequent upon the application of electricity. These accounts were written in a very candid and truthful style. The subject seemed very rife at that time, for Dr. Watson, Lovett, Wesley, Jallobert, Wilson, and Dr. Antonious de Haen were all mentioned as contemporaneous workers in the same field, and their efforts were apparently very successful.

Mr. PULVERMACHER exhibited and described an instrument intended to measure the smallest possible difference to be given to a patient in the form of a continuous current, the principle of which was based on the decomposition of water by the passage of a current of electricity.

Professor W. E. AYRTON, F.R.S., mentioned that his attention was first particularly turned to medical electricity in 1874 from a message being received by him from the Imperial Naval College in Japan, saying that a man had a swelling in his breast, and that death was imminent unless coagulation could be produced, combined with a request that he would assist in starting such coagulation electrically. Two needles were inserted in the swelling, a current passed, and coagulation set up by its aid, by which the man was saved. He then read Dr. Althaus' book on "Medical Electricity," and finding it stated that in certain cases the battery should be arranged in parallel circuit and in others in series, he made experiments in the resistance of the body, using plates a square centimetre in surface, and the results obtained agreed with what had been said by Dr. Stone and others, that the resistance was thousands of ohms. From this he gathered how little even the authorities on the subject knew about the subject they were writing on, and he therefore most heartily welcomed such a paper as that given them by Drs. Stone and Kilner, in which medical practice and exact electrical knowledge were combined. He advised the medical profession not to place too much reliance on a vertical galvanometer for absolute measurements, because the constancy of that form of instrument varied with the change of magnetism of the needle; whereas in the case of a horizontal galvanometer, in which the needle is of course unweighted, the constancy can only be changed by a change of strength of the magnetic field, and not by a change of strength in the magnetism of the needle. He asked for information as to whether any serious attempts have ever been made in hospitals of the effect of electrified air, and suggested that two wards under certain conditions could be experimented upon, one ward highly electrified, and the other in its normal condition.

The PRESIDENT: It is my duty to say that, as a Society, we are extremely indebted to Dr. Stone and Dr. Kilner for the very interesting matter which they have brought before us this evening. I do not remember that we have had many papers which have produced such a spontaneous discussion, but I will draw your attention to the fact that it is close upon ten o'clock. I really believe that if the meeting had been more largely attended the discussion might have extended far later. The subject of Dr.

Stone's paper contains much that is matter of enquiry, and I would ask whether any experiments have been made as to the electrical state of the human body when in perfect health. It is well known that in very dry states of the atmosphere, such as is frequent in North America, the static electricity on the surface of the body is sufficient to discharge a spark which can be used as a means of lighting the gas. The question in my mind arises, Can it be measured, and how? and does its measurement vary by age and in different states of health?

Dr. W. H. STONE, in reply, said the suggested use of a dynamometer, which had not occurred to him, was the first practical outcome of the paper. The paper was upon measurement, not bibliography nor biography. The voltameter was not suitable, on account of the varying nature of the resistance which took place in the human body, and no experiments had been made in the direction indicated by Professor Ayrton and the President.

A hearty vote of thanks was accorded to Dr. Stone and Dr. Kilner for their joint paper.

The PRESIDENT announced that Professor Dolbear, of America, was present, and would probably, after seeing the proceedings of that evening, be induced to favour the Society with a paper, suggested by Mr. Preece, on his telephonic system, at the next meeting, on Thursday, March 23rd, 1881.

A ballot for new members took place, at which the following gentlemen were elected, and the meeting adjourned:—

As Foreign Member:

J. Frayssinier.

As Members:

Colonel Richard Harrison, C.B., R.E.

Professor Silvanus P. Thompson, B.A., D.Sc., F.R.A.S.

As Associates:

Frederick Brown.
Nelson K. Cherrill.
Percy Stewart Fraser.
Lieut. Charles E. Gladstone, R.N.
Colonel Robert R. Jackson.
Rudolph H. Krause.
Hubert Musgrove Norman.

As Students:

Charles Bright.
Edward Stallibrass.

The One Hundred and Tenth Ordinary General Meeting of the Society was held on Thursday evening, 23rd March, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the last meeting were read and confirmed, and the names of new candidates announced and suspended.

The SECRETARY announced recent donations to the Library as having been received from J. M. Beard, Esq., and Mr. C. Walford, neither of the gentlemen being members of the Society. Books had also been purchased since the last meeting, particulars of which were given in the accession-book lying on the table for the inspection of the meeting.

The PRESIDENT: It is now my duty to announce a very pleasant fact. It may not be generally known, that the whole of the charges incurred in connection with the British Section of the Paris Electrical Exhibition were defrayed by the exhibitors themselves. The exhibitors formed a guarantee fund to the extent of £1,000, to be administered by the Commissioners. Of the amount guaranteed, 12s. 6d. in the £ was called up, and it proved more than sufficient, for, after all expenses had been defrayed, a balance of £110 5s. 3d. remained. A meeting of the guarantors was convened, and I have now the pleasure to announce to the Society, that a resolution, proposed by Mr. Foxcroft and seconded by Mr. Preece, "That the remaining surplus of the guarantee "fund, amounting to £110 5s. 3d., be handed to the Society of "Telegraph Engineers and of Electricians, to whose exertions and "co-operation much of the success attending the British Section was "due, with the request that they will devote it to a fund for the "purpose of presenting an annual premium for papers read before "the Society, the conditions of which the subscribers to the "guarantee fund leave to the Council of the Society, with the "suggestion that such premium should have some title which will "associate it with the Paris International Exhibition of Electricity "in the year 1881," was carried unanimously.

I think it is only right that our best thanks be given to the guarantors for their handsome gift.

Mr. H. C. FORDE: It gives me very great pleasure indeed, on this occasion, to comply with the President's request to move a vote of thanks to the guarantors. No doubt every member present will be glad to hear that such a "premium" fund has been started. A similar practice has operated very well in the case of the Institution of Civil Engineers, and in the case of this Society no doubt such a fund will stimulate its members to bring forward good papers. When people have devoted much time to the production of papers, it is pleasant to be reminded by premium or reward that they have done their duty towards the Society. The fact that all of the guarantors are members of the Society will give additional interest to the donation, and it is with very great pleasure that I propose a vote of thanks to them for their liberality. Some few years ago Mr. Fahie placed £100 in the hands of the Council, and if that be added to the amount now presented, the nucleus of a prize fund will be formed.

Mr. H. G. ERICHSEN: I have great pleasure in most heartily seconding the proposition.

The vote of thanks was carried unanimously.

The PRESIDENT: I have now the honour to ask Professor Dolbear, of whom we have all so often heard, and who was present at our last meeting, to favour us with the paper he has so kindly promised for this evening.

ON THE DEVELOPMENT OF A NEW TELEPHONIC SYSTEM.

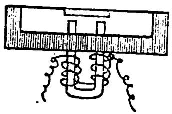
By A. E. DOLBEAR, Professor of Physics,
Tufts College, Boston, U.S.

In the attempt which I shall make to-night to show you something concerning the development of a new system of telephonic communication, I have thought that it will be best at the outset to go hastily over the history of electric telephony. Most of you may be more or less familiar with the main points, but if I devote a little time to historical research I may refresh your memory, and certainly hope thereby to make plainer the difference between the

ordinary telephonic systems and that which I shall exhibit to-night.

Amongst the earliest attempts made to transmit sounds through the agency of electricity, the first that I know of was that made by Dr. Page of Salem, Massachusetts, about 1837. His receiver consisted of a bar of iron, about which was wound a coil of wire, and he discovered that each time a current of electricity was passed through the coil and magnetism produced, a sound was given out. In his experiments Dr. Page used bars of considerable magnitude, such as two or three feet in length and an inch or more in diameter. It is understood by all that the sound under such conditions is caused by molecular disturbance—*i.e.*, the bar is lengthened, and each molecule of which the bar is composed has its position changed. With powerful currents the sound produced is heard as a click, and if the clicks follow each other with sufficient rapidity per second to cause the sensation of a continuous sound, of course a note or continuous sound is produced. By an automatic make and break arrangement, as a transmitter, Dr. Page with his electro-magnet got sounds sufficiently loud at times to be heard at very considerable distances, but I am not aware that his experiments went further than that, and of course with such a transmitter nothing but a certain definite pitch could be so transmitted.

The next attempt was one of which perhaps but little has been heard, made by Farrar, who lived in Keene, Southern New Hampshire, who proposed to transmit sounds of different pitches by the employment of the vibrating armature of an electro-magnet, of which the following is a sketch:—



By that device the vibration in the air set up by the motion of the armature produced sound when a suitable transmitter was employed. Farrar used one made of the reeds of a melodeon, the vibrations of which were arranged to make and break circuit, very much in the way as Helmholtz's tuning-forks have been employed, or, as is sometimes used in quadruplex telegraphy, the whole

operated by piano keys. Subsequently it occurred to Farrar that it ought to be possible to transmit the human voice, but though he spent some time in attempting to solve the problem, he did not succeed. He had some written communication with one of the foremost men of science in New England at that time as to whether such a device could be made, and as to its practicability, but the reply he received was so discouraging that he abandoned the attempt.

Next came Professor Helmholtz, who employed tuning-forks in connection with electro-magnets to reproduce sound at a distance; and then followed the attempts of Phillip Reis, of whom we have heard so much, but of whom we have not all heard the whole. Mr. Reis, it seems, undertook by himself to solve the problem of transmitting articulate speech. Suppose this problem was to come to any of you, or to me, to-day for the first time, having possession solely of the knowledge of electricity which was in the possession of men in those days. It was known at that time that a current of electricity would make a magnet at a distant place: it was known that a sound of a definite pitch could be reproduced at a distant place: the problem was how to make the vibration of the human voice bring about the varying conditions in a current of electricity that should reproduce at a distant place the form of vibration produced at the speaking end. It was known that vibration could be felt by one talking to a sheet of paper held in the hands; also that a hat may be felt to vibrate when held in the hand while a person of tolerably strong voice is talking. Reis knew that the vibrations of a drum would move a body so as to vary the contact of the body, and he applied that principle to modify a current of electricity.

It has been denied that it was then a matter of common knowledge that difference of contact made a difference in a current of electricity which traverses an electric circuit. Now, everybody who has ever set up a battery, from the time that batteries were invented until this day, knows that his first instructions were to make his connections good. And what for? For the simple reason that if his connections were not good he did not get the maximum current that he should get with his arrangement. Contact, then, was known as one of the elements of efficiency for a current in an

electric circuit. Reis started with this information. The material which he employed for his varying contact was platinum, and the specific device which he made was the ordinary one which is always pointed to whenever Reis's work is alluded to, so far as I know. There is a typical specimen before you [exhibiting a model].

The arrangement is that of a cubical wooden box, with a mouth-piece in its side, and a membrane on top placed in connection with the inner part, so that the vibrations of the air within the box shake the diaphragm. The diaphragm is more sensitive than the wooden material of the box, and by its carrying a small piece of platinum wire, which presses on a platinum strip, a current of electricity may be sent through the platinum junction, and the varying pressure resulting from the sound vibration has the effect of varying the strength of the current or breaking it, as the case may be, which depends upon the amplitude of the vibrations, and nothing else.

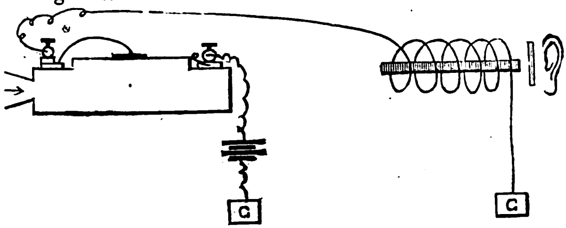


DIAGRAM 1.

Diagram No. 1 represents an instrument similar to the typical Reis transmitter, but having a shallower chamber. It was made by Albert, who was the instrument-maker for Reis, in 1863, and it, along with many other forms which he made, was exhibited at the Paris Exhibition.

Reis adopted at first for his receiver the identical form I have referred to as invented by Page—a straight bar of iron surrounded by a coil of wire, mounted on a box for resonant effects. The question is, will this receiver receive? If a current of electricity be sent through the wire, making it a magnet, its varying effects will depend upon the magnetism developed in it. If that varying magnetism be not fully destroyed, but only partially destroyed by a varying current, or what is known in these days as an undulatory

current, of course the lengthening and shortening of the bar will vary accordingly, and if it varies a sufficient number of times per second to give the sensation of sound, there will exist in that device everything essential for the reproduction of articulate speech. There is no defect in that arrangement, and so far as the principle is concerned it is all right, but it is evident that Reis got but meagre results from it. And why? The whole thing was mounted upon a box and set down on a table, evidently with the expectation of obtaining as loud a sound from such an instrument as that which was obtained from the ordinary telegraph instrument made in those days. It would not do that; neither will any instrument yet invented do so at the present day. In order to utilise the best acoustical instrument of this sort now extant, it is necessary that it be boxed up and fitted so that the undulations set up in the air can be brought close to the ear. The failure of the Reis receiver was due to the absence of the boxing-up, and not to any defect in principle.

It is singular that those who speak of Reis transmitters and receivers seldom pay any attention to any but his first instruments. I do not know why that should be: he invented other instruments. One was a form of electro-magnet, in which, instead of using the molecular motion of the magnet for the sound-producing conditions, he employed the vibratory motion of an armature to effect the same thing. Of course, in that arrangement, what is called induction was used. That was the second form of Reis transmitter, used in 1863.

On reflection it will be seen that Reis invented a transmitter which would vary a current of electricity, depending altogether upon the varying pressure brought about between two conducting surfaces when the surfaces were vibrated, and, as I said before, whether or not there was break of contact depended upon the amplitude of vibration of the membrane; and from many experiments made by myself, I can testify that such an instrument as that will talk, and will talk well, thus proving that the Reis transmitter will transmit. Secondly, his receivers will receive. There is no doubt about it at all. Nobody will challenge that, because they are all right in principle: one depends upon molecular work,

and the other upon the inductive vibratory action of an armature. With such instruments Reis did transmit articulate speech. I shall call this system the *Reis System.*

In 1876, Professor Bell put forward another system quite distinct from the Reis. He proposed, and I think he was the first one in the world to propose it, to speak to the armature of a magnet with the expectation that somebody else listening at the armature of another magnet in the same circuit might be able to hear what was said. His device you are all acquainted with. Diagram No. 2 contains an illustration of this arrangement. (In Diagrams Nos. 1 to 5, electro-magnets are shaded, and permanent magnets by indicated poles.) But the principle involved in Professor Bell's arrangement is altogether different from that involved in the Reis arrangement. In this case, when two electro-magnets are included in the same circuit with a battery, any motion of the

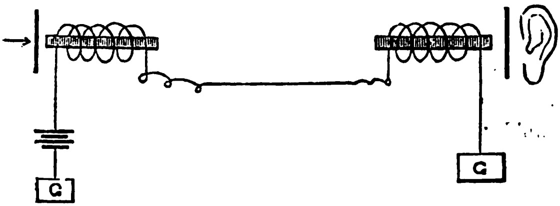


DIAGRAM 2.

armature of one will vary the current that is upon the line, because an electro-motive force will be induced upon that line which will traverse the circuit to or fro, according to the direction of motion of the armature, and so will increase or decrease the attractive strength of the other magnet, causing vibration of its armature. I say that this was a new system entirely distinct from the other.

An improvement on that was to dispense with the battery and electro-magnets, and employ permanent magnets in their place, and that condition is represented in Diagram 3. This was an invention of my own in 1876; but though the instrument could be used for 15 or 20 miles under certain conditions, its action was not reliable for long lines, and it became necessary, therefore, to find some means for making the telephone a more practical instrument. It did not

seem possible to make the permanent magnet arrangement or electro-magnet arrangement any more efficient than it was. If the magnet was enlarged, no increased effect occurred, and if the size of the diaphragm was increased, a maximum was very soon reached; if it was made thicker it would not move so freely, and so on. Attention reverted to the original Reis device, and many attempts were made to improve his transmitter, or find a substitute for it.

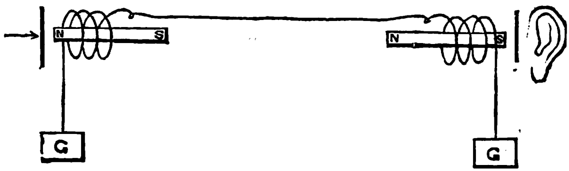


DIAGRAM 3.

Platinum was often tried, but was generally not very efficient on account of its liability to break on the one hand, and to fuse on the other. Mr. Edison proposed to use plumbago, and afterwards lampblack encased in a short cylinder, and the vibratory movement of a diaphragm upon them was to subject either the plumbago or the lampblack to varying degrees of pressure, and he found, or thought he found, that subjecting them to a pressure in that way would increase and decrease their resistance. Afterwards Professor Hughes discovered that gas carbon when in an unconstrained state

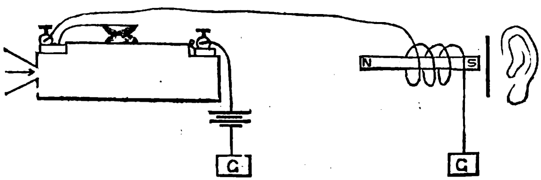


DIAGRAM 4.

was as efficient, or more efficient, than any other substance that had hitherto been appropriated to that use; and now when gas carbon is made to take the place of the platinum in the Reis instrument, we have one of the most efficient transmitters that has yet been invented. This is shown in No. 4 diagram, in which appears the identical instrument invented by Reis, in all of its features excepting that carbon is used as a substitute for the platinum.

Furthermore, it is coupled up with a magneto-telephone known as the Bell, and the arrangement is the original Reis system plus the permanent magnet.

A current of electricity is capable of doing a great many kinds of work. One of the kinds of work is to make an electro-magnet, and there are other kinds, such as heating a wire, moving a frog's leg, and varying the friction between moving surfaces. The latter is the principle applied by Mr. Edison in his motograph and motophone, when applied to telephonic purposes. Another instrument of this latter kind is one in which a cylinder of iron is surrounded by a coil of wire, within which it can be rotated, and having a U-shaped armature with its ends resting upon the ends of the magnet, and its bend fastened to the middle of a diaphragm. A current through the coil makes the bar a magnet, and the armature adheres to it. If the bar be rotated, the middle of the diaphragm is stretched, and an undulating current will vary the magnetic adhesion, and consequently the friction will vary, and cause the plate to vibrate with an amplitude varying with the current strength. That instrument was invented by myself, and I call it the "Rotophone." I have such an instrument before you. Of course there are many ways in which the property of electro-magnetism may be employed, and, as an interesting instance, I have here an ordinary sounder, capable of doing the ordinary sounder-work. Its armature has been broadened, and a mouth-piece fixed over it, the whole being made light, so as not to exceed the weight of the armature if unaltered, and this instrument makes a very nice telephone indeed, giving clear articulation with a single cell. Lastly, here is another device, which is an ordinary relay, the proper functions of which are not interfered with in the least, but to which I have an attachment, which is a short steel wire running from the plate and coming very near to the end of a pole; and any change in the magnetism of the poles of the magnets will vary the attraction which the magnet has on the wire, and the plate is vibrated accordingly. Such an arrangement is capable of doing very good work.

I wish now to come to the particular apparatus I have here to exhibit, and in order to lead up to that I would remind you of an

effect of so-called static electricity. Any one who has ever charged a Leyden jar, has probably noticed a sound emitted—a crackling and snapping—as the discharge takes place. That a charged body was capable of doing that was known for a long time; but the first experiment that I know of, in which such effects of condensers in any other form than those of Leyden jars was observed, was one made by Sir William Thomson in 1863, in which he had what is called an air condenser in connection with some submarine cable, and he observed, that as often as the condenser was charged or discharged, it produced a sound which he thought appeared to come from the air between the parts of the condenser. Afterwards Dr. Wright coupled up two pieces of silvered paper, back to back, and connected them with the terminals of a secondary coil, and with a Reis transmitter, and found that he was able, by the charge and discharge of a condenser made in that way, to have sounds reproduced loud enough to be heard in a hall of considerable size; but I have never heard that articulate speech was ever transmitted by that system. Afterwards Mr. Varley employed condensers of considerable capacity, and by charging and discharging, obtained sounds. I am not very well acquainted with the specific device which Mr. Varley employed, or the results which he got, but I do not understand that he got articulate speech from his arrangement, or that he attempted to do so. But although in my present apparatus I employ an air condenser which is affected by similar conditions, yet it is not true that I worked up to it from that direction. It may interest you to know how I did. It occurred to me at one time, that if I should pass a varying current of electricity through a substance which the electricity would decompose, and the decomposition of that substance would result in the liberation of gaseous material which should occupy a greater volume than the original material before it was decomposed, then I should have a means of setting up vibration by means of gaseous products set free in proportion to the strength of the current which traversed the solution.

Suppose the two plates in Diagram No. 5 to be separated by water, the elements of which are gases. A current of electricity that should decompose the water would bring about apressure

tending to separate the plates, and this pressure would vary as the decomposition was rapid or slow, which would in turn depend upon the strength of the current.

I expected that the front plate would vibrate under the conditions I have expressed, and by putting on a mouth-piece, and listening with the expectation that sounds would be produced, I found such to be the case. But during one experiment, I found that I got exactly the same result although all the solution had escaped through a leak in the chamber. I followed up the subject on the same lines, and developed from such conditions as those the present instrument. Here is an instrument, the case of which is hard rubber, in which a little flange is turned in the ring and keeps two plates separated from each other, with an air space between, neither being able to go beyond a certain distance. The plates are insulated from each other, each being connected to a suitable wire terminal. Before going further, I will say something about the electrical conditions present in such an instrument. It has been known, perhaps from the earliest days, that an electrified body would attract another body in its neighbourhood, no matter what kind of body. There is some difference in the strength of attraction, but everybody in the neighbourhood of another body that is electrified will be attracted by it. Suppose, then, [drawing on the board] a wire proceeding from a source of electricity with a body of any conducting material at the end of it. That body would be electrified, and if another body, say, a pith ball, be placed in its neighbourhood, it would be attracted to it. This is a case of action at a distance, a physical condition which is extremely interesting for very many reasons, philosophical as well as scientific. There is a great deal involved in that kind of action which we, as physicists, have yet to look after. If, instead of placing a pith ball near the body, I should put a plate near it, in its neighbourhood, but separated from it by means of any nonconductor, the electrical pulsations, on arriving and electrifying the plate, will attract the other plate, and we find that it is inductively electrified, and the effect of that induction is to make the plate move. If the plate is fixed at its edge, and made rigid round its circumference, it will slightly bend in the middle, and, when its tension has been disturbed in any way,

will afterwards fall back to its normal position. If the pulsations of electricity come in regularly, and with sufficient frequency to make the plate move more than twenty times per second up to the limit of audibility, 25,000 times per second, a continuous sound will be produced. The strength of the attraction will vary with the kind of material that is employed, with the electro-motive force acting upon the plates, and also with the shape and physical conditions of them. If the body be of considerable magnitude, the attraction will be very much greater, and if it be connected with the earth by means of a wire, there will be the conditions for the maximum amount of tension given by electrical excitation from a distance.

Suppose we look for a minute or two at the necessary conditions for getting a maximum amount of sonorous work (I will call it) out of a device of this sort, say, a disc. What are the conditions for maximum efficiency for sonorous result from a vibrating plate? The first must be that it freely moves—*i.e.*, that it is capable of having a certain amplitude of motion, free to vibrate unrestrained. If that be so, then the plate of the condenser which is next to the ear must be free, and must not be in contact with any other body which may in any way prevent its middle part from vibrating. Suppose, then, that we use an ordinary condenser [drawing on board] with several plates, each alternate plate connected to line, then the electric tension of each plate will be equal to that of every other one, and will be quite bound by the plate facing it, and will not add materially to the effect produced upon the end plates. If the dielectric has high capacity, absorption will take place—a condition that will interfere with the proper function of a telephone; and if the plates are tightly pressed together, as is usual, then in such a condenser we shall not have the maximum, but the minimum effect, as the plates must not touch if the maximum of sonorous vibration is to be obtained. Many persons have spent their ingenuity in such a device, but have all been wrong in such expectations. Herz has for some time worked upon a telephone of this kind, and has, I understand, increased his plates to as many as forty; but in my opinion the more plates used, the worse the telephone will be. Sonorous vibrations occur with such great rapidity in articulate speech, that it is an essential condition for

the maximum amount of work with the plates that they should not be capable of absorbing to any appreciable extent the electrical condition—*i.e.*, there must not be electrical absorption which shall interfere with its vibration; and therefore there is a limit to the magnitude of the plates and the character of the material that can be employed. I have worked with plates of all sizes, from those no bigger than the end of a wire up to plates two or three feet square; and although my instruments are tolerably small, I find that the small ones are just as efficient as any which I have been able to make, in the way of loudness and distinctness of articulation, and therefore I make all of this size.

Diagram No. 5 represents my present system. It is absolutely essential that I have a high electro-motive force, for it is electro-motive force which is the working factor in my instrument. The

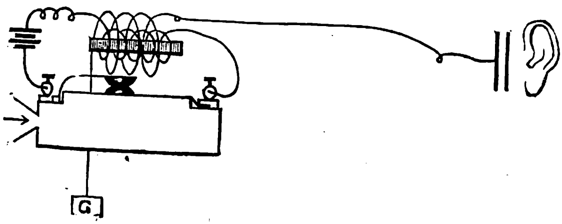


DIAGRAM 5.

arrangement shown in Diagram No. 4 is not suitable, as there would not be sufficient electro-motive force. There are two or three ways in which I can use a transmitter. One of them is by means of an electric machine. Suppose that the source of my electricity, instead of being a battery of one or two cells and the ordinary device, should be a plate electrical machine, I should get an ordinary jumping spark, or, in other words, a current of electricity which would pass a certain space in air, and if joined to a transmitter the sounds from the sending point would be heard at the receiver. If, instead of that, I take an ordinary induction coil having a sufficient number of turns, and giving a proper resistance, from 2,500 ohms to 3,000 ohms, which in practice I find to be about the best, I shall then have the means for getting the high electro-motive force that is essential for the working of this instru-

ment. In this case I shall have the device represented by Diagram No. 5, in which I have a Reis transmitter, plus the carbon points, with a secondary coil, connected to one of the plates of my receiver. The undulatory current in the primary coil sets up varying electro-motive forces in the secondary coil sufficient to work the instrument, and as the electro-motive force is high, external resistance is a very small factor indeed, and the length of wire through which it will work is almost unlimited.

I will now exhibit the working of this instrument. Several receivers on one circuit are distributed around the room, and a transmitter is in an adjoining room. My wire is not very long, but it is sufficient to show the action of the system. The transmitter is as I have explained to you. The working instrument, battery and all, is now before you. A single bichromate cell is joined to the transmitter, but sometimes I use a chloride of ammonium cell.

[Counting, whistling, and an air played upon a cornet were here heard distinctly by the entire audience.]

I said a little while ago, in speaking of the system, that an electrified body would attract any kind of body, but that the strength would vary with the strength of current and kind of material, and so it is; but it is not at all essential that the second plate should be in connection with the ground—*i.e.*, the ordinary condition for bringing what is called an electric circuit into use is not necessary or essential at all, but the end may be left free. Here is a receiver with a single terminal, and sounds are as distinctly heard from it as from those with the completed circuit. In it the bottom plate is connected with a ring of metal, and my hand being in contact with that ring places my body in the position of an enlarged terminal. But I would not have you to think that even such a condition as that is at all necessary, for here is an instrument which has only one plate and one terminal, and if it be connected with the wire from the transmitter, there is no difference between the sound emitted by this receiver and that given by the others with two plates, except in loudness.

The PRESIDENT: The articulation is perfectly clear, only not so loud as from the other instruments.

Professor DOLBEAR: It is simply the vibratory motion of one plate acting inductively on a plate of rubber which is immediately in front of it. But I have one step more which I think will interest you. Here is the same instrument to which you were listening a minute or two ago. I have found that it is not necessary to have the receiver attached to the circuit at all to produce results. I have now completely disconnected it from the instrument, and will ask the President to state the result.

The PRESIDENT: I hear the sound perfectly. It was about as loud in my ear as the cry of a new-born kitten.

Professor DOLBEAR: The system which I have described needs only a few concluding words as to some of its advantages, and why I describe it as a new system. The first system, that of Reis, was one in which the electricity is transformed into magnetism, and the magnetism is transformed into the vibratory motion of the plate. There are two transformations in that case, involving, of course, a correlation of forces. In this case, the electrical transformation is but a single one; the electrical difference of potential itself is immediately transformed into motion, without intermediate magnetism, and I have therefore a right to speak of it as a new system. The simplicity of the instrument is very great indeed. I can hardly conceive how it is possible to make anything simpler. It [holding one] consists of two plates in proximity encased in hard rubber, having a knob for a handle upon one side, and an aperture to listen at on the other, and I have heard with such an instrument as this fifty feet from the terminals, so that it is only necessary in this case to bring the wires anywhere in the neighbourhood of the listener, who, provided with receivers, can hear what is said. In magnetic receivers, where current electricity is employed, of course the question of resistance is a consideration, and comes under the application of Ohm's law, but in this case it is not at any rate within the limits of manipulative figures. The cost of the apparatus is nothing very great—it is about the same as that of the other system. As for what it will do, I will simply tell you what I have done with it. I have had a line between my lecture-room and my residence, about half a mile long, which has been fitted with this system for two years, and was going when I left home the other

day as well as it was at first, and the battery has not been taken out or attended to in any way beyond replenishing the evaporated water a couple of times. I have used the system on tolerably long lines—lines running out from the City of Boston 2 miles, 10, 40, and 256 miles to New York City; the latter the telegraph wire of the Rapid Telegraph Company. I have used this system on the wires of this Company on two occasions, the first being a very rainy one, after two or three days' rain, so that the line of poles on which the wire was stretched were quite as wet as could be, and I expected a perceptible loss from leakage; but, as a matter of fact, there was no special trouble, and the sound was not materially different from the time when the weather and line were perfectly dry. Long sentences could be heard without a single break, and inductive trouble was mostly absent, though at the same time the other system was unworkable from that cause. Some induction could be heard when there was nothing else to listen to, but when conversation was passing it was not troublesome. As to what it is capable of doing beyond that, I have not had an opportunity of trying, but so far I can testify from my own experience. Thanking you for your attention, I will simply say, in conclusion, that if there are any present who wish to listen to the instrument after the adjournment of the meeting, I shall be glad to give them an opportunity of doing so, or if they will come down to my office, at 31, Queen Victoria Street, I shall be glad to show them the instrument more at their leisure.

The PRESIDENT: Before asking you for a vote of thanks, which I am sure you will all cordially agree in contributing and offering to Professor Dolbear, I will ask if there are any gentlemen present who desire to make a few remarks as to what we have heard, reminding them that the hour is late.

Mr. WILLOUGHBY SMITH: Sir,—It was not my intention to speak this evening, but a very remarkable coincidence impels me to do so. In the early part of the present year, I offered to this Society a paper on "Induction," but an evening for reading the same has not yet been named. I was prepared to have shown, that by placing a flat spiral of fine silk-covered wire in the centre of this

room, the spiral being connected to a suitable transmitter and battery, that every person present possessing a telephone would have been able to have heard whatever sound was influencing the transmitter, although the telephones were in no way attached to the circuit.

When a spiral formed of any electric is influenced by intermittent currents of electricity, lines of force proceed from the same; and it appears that, if a telephone be placed so as to intercept any of them, sound will be produced in the telephone. My apparatus is in working order, and I should be pleased to repeat my experiments to any gentleman who will favour me with a call at 18, Wharf Road, City Road, any time to-morrow. The results are remarkable, and I had hoped to have brought them before you ere this; but, as it is, we have another illustration of two brains working at the same time in the same direction.

The flat spiral referred to is three feet in diameter, and has a resistance of 122 ohms: it consists of 800 turns, and the whole length is 1,220 yards.

Professor W. GRYLLS ADAMS, F.R.S.: If I may be allowed, Sir, I should like to express the very great delight with which I, as well as, I have no doubt, all present in this room, have listened to the clear and complete account of the history of the telephone from its earliest up to its very latest phases, even up to the inventions, I may say, almost of to-day. In expressing this, I should also wish to draw attention to one point in connection with Reis's telephone, of which Professor Dolbear has given such a clear account. I think Professor Dolbear stated that in 1863 Reis was experimenting with his telephone. In 1864, if I mistake not, there was a slight modification made in Reis's telephone by Mr. Yeates of Dublin, who introduced a drop of liquid between the platinum point and the plate of the transmitter, thereby improving the contact, and giving the opportunity for more delicate variations of contact or resistance than were possible before, so introducing a modification which must be considered an improvement in the instrument as it stood at that time. The result of the slight modification introduced by Mr. Yeates was that certainly sounds and speech could be heard through that telephone far better than they could be

heard before, so that, as a speaking instrument, it was an advance on Reis's telephone. I have thought it well to draw attention to this, because this modification was an improvement introduced so long ago, and therefore it might be well to connect Mr. Yeates' name with this complete history of the telephone which Professor Dolbear has given us so very clearly and in such an interesting way this evening.

The PRESIDENT: It is nearly five years since many of us had the pleasure of hearing Professor Bell describe what was then to most of us a perfectly novel idea, which has since brought forth all over America and Europe an industry the size of which very few of us can compute, and the size of the future of which none of us can form an idea, viz., the use of apparatus for the communication of articulate speech. Since then there has been brought before this Society very little further information on the subject in the shape of papers. We greet our brother from America, a fellow-worker with so many in this Society, for having after five years again brought the same subject before us with fresh interest, fresh ideas, and fresh prospects in the future. In our library will be found all the papers, pamphlets, and patents which bear on this subject. By any one who is interested in it, the pamphlet of Professor Barratt, the pamphlet of Elisha Gray, and the paper which was read by Professor A. G. Bell before our Society, will be found a mass of reading which at this moment, after having heard what Professor Dolbear has said, will be full of interest. The question of priority of invention or idea, is not one without interest to a Society like ours, but it is not for us to decide; we are only glad to hail the announcement which Professor Dolbear has made to us, and which we hope, as people who are outside the prejudices of the various interests connected with these inventions, will be the means of placing telephony free at the disposal of every human being.

It is now late, and any remarks from me are unnecessary. It will become the duty of one of our members to propose a vote of thanks to Professor Dolbear, and I will ask Mr. Preece to do so.

Mr. W. H. PREECE, F.R.S.: I cannot resist re-echoing what you and Professor Adams have said of the delight and pleasure

that I have felt in listening to Professor Dolbear expounding his views so simply and so clearly, that the most ignorant amongst us must fully comprehend what he meant. There is nothing more marvellous than the wonderful universality of this power which electricity possesses of making everything reproduce speech. Now that we know what electricity can do, the difficulty appears to be, not so much how to make apparatus speak, but how to prevent it from speaking. A very curious instance came beneath my notice in the very early days of telephony, some four years ago, when two men in a carpenter's shop (I think it was at Worcester) heard a conversation, and those who were conversing by telephone were certainly 100 yards away from the carpenter's shop, and out of earshot. The only connection between those who spoke and the carpenter's shop was the fact that the wire connecting the telephones rested upon the carpenter's bench, and upon that very spot there happened to be a bad joint, and there is no doubt whatever in my mind that that bad joint was a good telephone, and it repeated the words that were spoken at the other end.

Of course, as our President has remarked, as this question of priority of patent is at the present moment before the Courts, it would be unfair and unjust for any one to express an opinion, and particularly for any one to express an opinion who would very likely be subjected to the unpleasant ordeal of a subpœna; therefore I do not intend to say one word on that point. But I do say this: that if the power of conversation by the variation of electric currents is to be made a monopoly, then there must be something very rotten in our Patent Laws, and something that urgently requires reformation. Mr. Willoughby Smith has alluded to the fact that two brains have been working in the same direction at the same time. Now, there is something still more curious, and that is that three brains have been working in the same direction at the same time. The third brain is not my own, but that of Professor Hughes. Certainly two years ago Professor Hughes showed to Mr. Spottiswoode, Professor Stokes, myself, and several others, some very curious experiments, which were exactly in the direction that Professor Dolbear has shown us to-night, and which Mr. Willoughby Smith has described, and that is that sounds were

reproduced across air at the extreme distance his rooms allowed us to stand away from the instrument. Professor Hughes attributed the effect to conduction; but whether it be the effect of conduction or induction he has not yet proved, for he has not published his investigations.

The phenomena that Professor Dolbear has shown us in his beautiful experiments, and which he has converted into telephony, are far more than the mere attraction and repulsion of electrified masses. There is something further—there is something (as Professor Dolbear said) there for physicists to examine; in fact, a new field for them to explore. Most or perhaps all of you have studied the works of our great master and apostle, Faraday. It is well known how he sought to discover that which he called "an electro-tonic state"—a peculiar state of matter which existed between the positive and negative discharges due to induction and other causes. I think that in the telephone of Dolbear, if Faraday had been alive, he would have said, "Here is something that will help me to discover my electrotonic state." All who work in this field must feel how wonderfully prolific the discoveries of philosophers are when they come into the hands of practical men, and when they are fostered and encouraged by such workers as Professor Dolbear. Your appreciation of his work is testified by such applause as that you have given to him to-night, and which I trust you will also give to the motion which I have now to propose, viz., "That a vote of thanks be given to Professor Dolbear for the very clear and able statement he has laid before us to-night."

Professor G. C. FOSTER, F.R.S.: I am sure there is no need that I should spend many words in seconding the vote of thanks that has been so ably proposed by Mr. Preece. I do so with very great heartiness, and feel great pleasure in having the opportunity of expressing the interest with which I have listened to Professor Dolbear's very able and instructive address. One special point of interest occurred to me,—but one which has doubtless occurred to others also,—namely, the great variety of electrical effects which have, by one method or another, been made the means of producing sound and telephonic effects. Reis's instrument depended on the phenomenon of the "magnetic tick:" Professor Graham Bell employed

magnetic attraction. The chemical action of the current is taken advantage of in Edison's so-called "motophone;" and we have the same action applied in another form in the experiments of which Professor Dolbear has told us to-night, wherein sound is generated by the variation of volume caused by the intermittent production of gas; while, in his latest form of telephone, the principle we have applied is the electrostatic attraction between differently electrified bodies. It thus appears that there is scarcely any kind of electrical effect which cannot, under proper conditions, be made the basis of a system of telephony.

There is no need that I should say more than that I second, with very great pleasure, the vote that has been prosposed.

The PRESIDENT: The applause which followed the proposal of Mr. Preece and the speech in which Professor Carey Foster seconded the motion, shows that there is no necessity to put it to the vote.

Professor DOLBEAR: I should be very glad to say something to express my gratification for the reception accorded me to-night, but I have already talked so long that I beg to be excused from doing so further to-night.

ORIGINAL COMMUNICATIONS.

Communicated by Lieut.-Col. Bateman-Champain, R.E., Past President.

Extract from a Letter of Mr. Mance, dated Karachi, 1st *February,* 1882 :—

"I have the honour to report that, in stripping a piece of gutta percha cable picked up in September last, 70 miles west of Jask, the tooth of a saw-fish was found firmly embedded in the core; the point of the tooth has passed completely through the percha, just missing the copper wire.

"It has been suspected on more than one occasion that a saw-fish has been the cause of previous faults, but this is the first time it has been proved beyond a doubt that our gutta percha cables are liable to injury from the attacks of these fish.

"The tooth has evidently been held fast between the iron guards and wrenched out."

THE LECLANCHÉ BATTERY.

By W. H. Preece, F.R.S.

When at Paris last year, attending the International Exhibition I was informed by Mr. Collette, the Engineer to the Telegraphic Administration in Holland, that he had abandoned the use of peroxide of manganese in Leclanché batteries, and that he found they worked equally well without this material. To test the value of this assertion, I had four Leclanché batteries fitted up, two of which contained six cells of the gravity form, and two ten cells of the form at present in use by the Post Office Department. One battery of each kind was fitted with the usual mixture of broken carbon and peroxide of manganese, and the other two with broken carbon only. The four batteries were charged with sal-ammoniac, and filled up with fresh water in the usual way.

These batteries were fitted to two metropolitan circuits on November 11th, and when they were examined on the 5th January, 1882, the cells charged with peroxide of manganese were

found to be still in very good working order, while those prepared with broken carbon alone were practically pumped out. When they were first fitted up they each gave the same resistance and the same electro-motive force, but on testing them about a week afterwards, although the resistance had not changed, the electro-motive force of those without peroxide of manganese had run down considerably. They were tested again on the 9th December, and it was found that the electro-motive force of those charged with peroxide of manganese was more than 50 per cent. greater than those not so fitted up. They were again tested on the 3rd January, when it was found that the electro-motive force of the cells charged with peroxide of manganese was exactly double that of the others. Both batteries without peroxide of manganese failed on the 5th January, as previously stated.

It is therefore quite evident that, however well the Leclanché battery may work without peroxide of manganese, it works infinitely better with it.

On submitting these facts to Mr. Collette, he informed me that he had also found a difference of electro-motive force between the elements with and those without peroxide of manganese, but the difference was much less than that which I had indicated. Experiment had shown that he can work with fewer elements containing peroxide of manganese, but he had never found the number double, as I had indicated. He was content to use more elements, owing to their facility for renewal and repair, for the interior resistance remains fairly constant,—a matter of some consideration for batteries serving many lines on the universal principle—a practice much adopted in Holland, and which gives very good results. These were his reasons for not returning to the use of peroxide of manganese for the Leclanché batteries in use in the Dutch service. Above all, it appeared to him that the chemical work done in the battery by the peroxide of manganese is not yet perfectly understood. The depolarising action of the manganese appears to be very doubtful.

These reasons may hold good when the number of cells in use is few, but they are scarcely tangible when the number of cells in use is so great as it is in England. There are over 42,000 Leclanché cells at work in the British Post Office service.

ABSTRACTS.

LORD RAYLEIGH—EXPERIMENTS TO DETERMINE THE VALUE OF THE BRITISH ASSOCIATION UNIT OF RESISTANCE IN ABSOLUTE MEASURE.

(*Royal Society*, 1882.)

This paper contains an account of a repetition by Lord Rayleigh, Dr. Schuster, and Mrs. Sidgwick, of the British Association experiment on the unit of resistance with an improved apparatus. Three distinct series of observations were taken, of which the two first were more or less imperfect. In the third series an extraordinary concordance in the results obtained on different occasions at the same speed of rotation was arrived at, but the numbers corresponding to the four speeds could not be perfectly harmonised on the basis of an *à priori* calculation of the self-induction.

TABLE VII.—THIRD SERIES.

Number of teeth	60	45	35	30	Mean.
Resistance of standard at 13°, uncorrected... ...	23·619	23·621	23·630	23·638	23·627
Correction proportional to square of speed	0·006	0·011	0·018	0·025	
Resistance of standard at 13°, corrected	23·613	23·610	23·612	23·613	23·612

Table VII. gives the results of the series. The "number of teeth" in the first row is inversely as the speed of rotation. The second row gives the resistance of a certain platinum-silver standard at 13° in absolute measure, as calculated with a value of the self-induction derived from evidence independent of the spinnings. The simple mean of these numbers is 23·627 ($\times 10^9$ C.G.S.), but they exhibit a well-marked tendency to rise with the speed. In the third row are numbers proportional to the squares of the speeds, by subtraction of which a practically perfect agreement is arrived at. The mean 23·612 thus represents the result of the investigation, if the effect of self-induction be determined from the spinnings themselves, and is to be preferred, for reasons explained in the paper, to the simple mean 23·627. The difference is, however, less than one part in a thousand.

The resistance at 13° of the same coil in terms of B.A. units is 23·935, from which we find

$$1 \text{ B.A. unit} = \cdot 98651 \frac{\text{earth quadrant}}{\text{second}}.$$

This number is somewhat lower than that which we obtained (·9893) with the original apparatus,* but it agrees with that required to reconcile Dr. Joule's thermal determinations. Rowland's value is distinctly higher (·9911), while Kohlrausch obtained 1·02. No satisfactory reconciliation of these results is arrived at, but some remarks are made upon the relative merits of the various methods.

H. S. MAXIM—AUTOMATIC FIRE-ALARMS AND EXTINGUISHERS.

(*L'Electricien, T.* 2, *Nos.* 21 *and* 22, 15*th Feby. and* 1*st March*, 1882, *pp.* 489, 491.)

In the first arrangement described, which is entirely mechanical, a system of pipes is distributed about the stage and other parts of the theatre. These pipes are in connection with the pressure service mains or with a reservoir, and the openings are provided with cocks controlled by a system of levers. The levers are kept in a vertical position by means of cords stretched across the stage and in certain other parts of the theatre. Should a fire break out at any point, the cords will be burnt through, the corresponding levers will be released, and, falling into a horizontal position, will open the cocks, and the water under pressure in the pipes will be forced out at the point where the fire originated.

In the second arrangement a strong iron cylindrical reservoir is provided, full of water, and having a layer of chalk placed at the bottom. At the top of the cylindrical chamber is placed a glass vessel containing sulphuric acid, into which dips an iron plunger, sliding through the cork of the bottle, and projecting above it. Above this plunger, and so arranged as to fall upon it, is a lever with a heavy counterpoise, which is normally held up by a small catch. This catch can be released by an electro-magnet as soon as a current passes. The hammer then falls on the plunger, which is driven through the bottom of the glass bottle, and the sulphuric acid is discharged into the chamber, where it at once acts on the chalk, disengaging large quantities of carbonic acid gas, which produce sufficient pressure to force the water up the delivery pipe to the top of the theatre. The presence of the carbonic acid in the water is an advantage, but the same thing cannot be said of the sulphuric acid.

In the third arrangement the delivery pipes are severally in connection with the service pipes, each section being cut off by a cock. This cock can be opened by the falling of a weighted lever, as in the first arrangement, but the release of the lever is effected by an electric current automatically closed. The lever is held up by a catch at one end of a short lever, the other end of which is just above an electro-magnet. As soon as the current passes, the one end of the lever is pulled down, the catch is released, and the weighted lever falls, opening the valve. The automatic circuit-closer consists of two straight springs kept apart by a small plug of fusible metal, which is insulated on the surfaces where it touches the springs. As soon as a fire breaks out the plug of metal melts, the two springs come together, and the circuit is closed. Besides

---

* *Proc. Roy. Soc.*, vol. 32, p. 141.

actuating the releasing lever of the electro-magnet, this current also fires a small charge of gun-cotton or other explosive, contained in a cap covering the nozzle of the delivery pipe, and thus gives free egress to the water.

M. DEPREZ—ON ELECTRIC ACTIONS IN SIMILAR CONDUCTING SYSTEMS.

(*L'Electricien, T.* 2, *No.* 22, 1*st March*, 1882, *p.* 504.)

In a paper read before the "Académie des Sciences," M. Deprez investigates the changes produced in the electrical properties of a conductor when the linear dimensions are changed. Calling i the intensity of the current in a conductor of section a, the stress between two elements ds and ds^1, at a distance apart r, and enclosing an angle θ, will be $dF = i^2 \frac{ds, ds^1}{r^2} f(\theta)$, which may be written $dF = \frac{i^2}{a^2} \cdot \frac{a\,ds, a\,ds^1}{r^2} f(\theta)$, but $a\,ds$, $a\,ds^1$ are the volumes dv and dv^1 of the two elements; hence we have

$$dF = \frac{i^2}{a^2} \cdot \frac{dv, dv^1}{r^2} f(\theta).$$

If now all the linear dimensions are increased in the ratio k, dv becomes $k^3\,dv$, dv^1 becomes $k^3\,dv^1$. r becomes kr, while θ does not change; the new stress will therefore be

$$dF^1 = \frac{i^2}{a^2} \cdot \frac{dv, dv^1}{r^2} \cdot f(\theta) \times k^4.$$

Thus, when all the linear dimensions of a conducting system, of any form whatever, are increased in a fixed ratio k, without changing the flow of electricity which circulates in the unit section of the wire, the elementary forces increase as the fourth power of k, and therefore also their resultants. If the conducting system is a dynamo machine, we know that the work per second is represented by $T = FV$, where F is the resultant of all the elementary forces, and V is the velocity. Increase all the dimensions of the dynamo in the ratio k, but keeping the wire of the same section, then F becomes $F\,k^4$, and V becomes $V\,k$; and we now have $T^1 = T\,k^5$, *i.e.*, the work increases as the fifth power of the ratio. If R is the resistance of the conductor, E the opposed E.M.F. produced by the displacement of the moving part, L the length of the wire, V its volume, a its section, and c its conductivity, we have

$$I = \frac{E}{R} \text{ and } R = \frac{L}{a\,c} = \frac{V}{a^2\,c},$$

$$\text{but } V = k^3 \;\therefore\; R = \frac{k^3}{a^2\,c};$$

$$\text{then } I = \frac{E\,a^2\,c}{k^3}, \text{ and } F = \frac{E^2\,a^4\,c^{2}}{k^6\,a^2} \times k^4;$$

$$\therefore F = \frac{E^2\,a^2\,c^2}{k^2}.$$

On the other hand, if Q is the quantity of energy received by the conducting system,

$$Q = \frac{E^2}{R} = \frac{E^2 a^2 c}{k^3}.$$

$$\text{Hence}\quad \frac{F}{Q} = k\,c.$$

If the volume and the form are invariable, k is invariable, and therefore the ratio F/Q is invariable, *i.e.*, to produce the same force, F, the same quantity of energy, Q, must always be expended. If C, the conductivity, is increased, Q is diminished, *i.e.*, less energy is required to produce the same force. It is also evident that, if all the dimensions are increased in the ratio k, k times less energy is necessary to produce a force F. From this it seems that large dynamo machines are advantageous. Not only are they more powerful per unit of mass, but they are also more economical.

E. EDLUND—THE ELECTRICAL RESISTANCE OF VACUUM.

(*Philosophical Magazine, S. 5, Vol. XIII., No. 78, January,* 1882, *pp.* 1-20.)

A great number of experiments, made by several physicists, all go to prove that when a Torricellian vacuum is produced in a tube, the last particles of air having been got rid of by prolonged boiling, a current will not pass between the electrodes at the ends of the tube. The author proceeds to prove that this insulation is not due to the vacuum, but that, on the contrary, vacuum in itself is a conductor.

Amongst the numerous results of the experiments, some are of special interest. Gassiot, experimenting with carbonic acid gas and potash, found that the discharge between two platinum wires continually varied as more and more gas was absorbed, until a point of rarefaction was reached when the discharge would no longer pass; but he could still produce induced currents in the vacuous tube. Gaugain introduced into his vacuum tube a strip of tinfoil at right angles to the path of the current, and the tinfoil then showed opposite polarity on its two sides. On approaching the electrodes a small hole was punctured in the tinfoil by the current, which then passed exclusively through this minute hole, showing that the tinfoil did not act as a conductor. Plücker found that, after the direct discharge would no longer pass between two platinum electrodes, he could still cause induced currents, and that after some time a discharge could again be produced. This he explained by the absorption of the small amount of air remaining in the tube, which was afterwards again given up. Hittorf could not get a discharge between electrodes 2 mm. apart, but that instead the current passed over the outside of the tube.

We see, then, that when the limit of rarefaction has been reached at which the direct discharge will no longer pass, it is possible by induction to excite a current in the rarefied gas. It seems that it is not, then, the want of conductibility of the vacuum which prevents the direct discharge, since the assuredly weaker influence currents can still be produced. It is rather in the electrodes

that the cause is to be sought which hinders the passage of the current from them to the gas, or *vice versâ*.

Several experiments bearing on the point are cited by the author. Thus M. E. Becquerel found that if the two electrodes were of different sizes, the apparent resistance of the gas was greater when the current passed from the larger to the smaller, and that the material of the electrodes had an influence on the resistance. Schultz remarked that if the pressure of the gas was greater than that at which the minimum of difference of potential was presented, the difference of potential necessary for the discharge increased, all other circumstances being equal with the distance between the electrodes; when, on the contrary, the pressure of the gas was less than the limit, the difference of potential was independent of the distance. Similar results have also been obtained by Wiedemann, Naccari, and Bellati.

It seems, then, that the obstacle which a rarified tube presents to the passage of an electric current is of a twofold nature, part of the resistance r^1 being due to the gas, and part r existing at the surface of the electrodes, and that therefore the total resistance may be represented by the expression $r + r^1 l$. The point of rarefaction at which the limit is reached when the current will no longer pass, is dependent on the distance between the electrodes, the width of the tube, the area of the negative electrode, and some other circumstances. But since r^1 diminishes constantly with diminishing pressure, as experiment has proved, the subsequent increase of resistance after turning-point is reached must be due to r. We thus arrive at the following deductions, which entirely conform to the experiments quoted in the paper:—At the ordinary pressure r is very small in comparison with r^1, and it is evident that then the tension is proportional to the distance, since, in this case, in the formula $r + r^1 l$, r can be neglected. As the pressure diminishes r increases, while r^1 decreases; the difference of potential therefore varies with the distance, but is no longer proportional to it. At a very low pressure r^1 becomes very small, and can be neglected, and the difference of potential is then independent of the distance between the electrodes. Hittorf has found that r^1 continually diminishes even to so low a pressure as 0·003 mm., but that r increased and was dependent on the material of the negative electrode.

According to the author, therefore, the fact that a vacuum tube highly rarefied is not a good conductor does not depend on a high resistance of the rarefied gas, but is the consequence of an obstacle to the passage of electricity from the surface of the electrodes to the gaseous medium. As the true resistance of the gas diminishes as its rarefaction increases, we must conclude that absolute vacuum is in itself a good conductor.

E. EDLUND—ON THE ELECTRICAL RESISTANCE OF GASES.

(*Philosophical Magazine*, *S.* 5, *Vol. XIII.*, *No.* 80, *March*, 1882, *pp.* 200-212.)

The resistance opposed by gases to the propagation of electricity has shown itself to be different in several respects from that produced by solid or liquid conductors. These differences may be tabulated as under:—

Solid and Liquid Conductors.	*Gases.*
1. However small the E.M.F., there will always be a current, and only when the force is nil will the current be nil.	1. There is a minimum limit of E.M.F. below which no current passes.
2. The heat produced is proportional to the square of the current.	2. The heat produced is proportional to the first power of the current.
3. The heat produced is inversely proportional to the cross-section of of the conductor.	3. The heat produced is independent of the cross-section.
4. The same holds for the resistance.	4. The same holds for the resistance.
5. The difference of potential of two points is proportional to the product of the resistance between the points and the current.	5. The difference of potential is independent of the current.
6. The resistance increases with the temperature.	6. The resistance decreases when the temperature is increased or the density diminished.

The author considers that these differences can be readily explained by starting from his unitarian theory of electricity. According to this theory, the galvanic current in a closed circuit consists in the free ether present in the circuit being set in translatory motion. The intensity of the current is determined by the quantity of ether passing any section in unit of time, and, for equal intensity of current, the velocity of the ether is inversely proportional to the magnitude of the section.

He first shows how the above six laws may be proved for solids and liquids, and then proceeds to consider the case of gases. Experiment has proved that in order to compel a current to pass through a column of gas a determined electric tension is necessary; if the tension is below the limit the current will not pass. It is true that the whole of the insulating property of a gaseous column is not due to its own resistance alone, but that there is set up at the electrodes a resistance which prevents the propagation of the electricity by the gas. The E.M.F.'s which have their seat upon the electrodes having no connection with the distance which separates the latter, it follows that, when the gas has sufficient density, it is chiefly its resistance that constitutes the true cause of the discharge not taking place if the electric tension remains below a certain limit. We arrive, therefore, at the result, that the resistance opposed by a gas to the propagation of electricity cannot be proportional to the intensity of the current.

Admitting the above to be true, all the differences can be explained on the unitarian theory. Let k be the counter-pressure opposed to the current in a column of gas of unit length and unit section, the total counter-pressure in a column of section a will be $k\,a$, not $k\,i$ as in solids and liquids; and if h be the velocity of the ether, then $k\,a\,h$ is proportional to the mechanical work done in unit of time; and since $i = \delta\,a\,h$, the mechanical work done in a

column of unit length and section, a will be $\frac{k\,i}{\delta}$, to which also the quantity of heat developed in the same circuit must be proportional. The quantity of heat, therefore, is proportional to the first power of the current, and is independent of the section of the column of gas.

The resistance being determined by the counter-pressure which the conductor opposes, on the unit of section, to the propagation of the electricity, and this counter-pressure being, in gases, independent of the intensity of the current, it is self-evident that the resistance of a column of gas must be independent of its section.

The difference of potential between two points being proportional to the resistance between these points, in solids and liquids this difference of potential will be proportional to $r\,i$, but in gases to $k\,l$.

If r is the principal resistance in the part of a closed galvanic circuit composed of solid and liquid conductors, R the resistance of a column of gas in the circuit, the equation of motion will be

$$L\frac{d\,i}{d\,t} = n\,E - n\,R - n\,r\,i,$$

from which, when the current is constant

$$i = \frac{E - R}{r}$$

The resistance of the gas has therefore, in reality, its place in the numerator of Ohm's formula. Of course E — R must have a positive value for a current to be possible.

THE SOCIETY OF
Telegraph Engineers and of Electricians.

COUNCIL.—1882.

President.
LIEUT.-COLONEL C. E. WEBBER, R.E.

Past-Presidents.
CHARLES WILLIAM SIEMENS, D.C.L., F.R.S.—1872 AND 1878.
FRANK IVES SCUDAMORE, C.B.—1873.
SIR WILLIAM THOMSON, LL.D., F.R.S.—1874.
LATIMER CLARK, C.E.—1875.
C. V. WALKER, F.R.S.—1876.
PROFESSOR ABEL, C.B., F.R.S.—1877.
LIEUT.-COL. J. U. BATEMAN-CHAMPAIN, R.E.—1879.
W. H. PREECE, F.R.S.—1880.
PROFESSOR G. C. FOSTER, F.R.S.—1881.

Vice-Presidents.
WILLOUGHBY SMITH.
PROFESSOR W. G. ADAMS, F.R.S.
C. E. SPAGNOLETTI, M. Inst. C.E.
PROFESSOR D. E. HUGHES, F.R.S.

Members.
W. S. ANDREWS.
WILLIAM T. ANSELL.
SIR CHARLES BRIGHT, M. Inst. C.E.
E. B. BRIGHT.
THE EARL OF CRAWFORD AND BALCARRES, F.R.S.
H. G. ERICHSEN.
H. C. FORDE, M. Inst. C.E.
MATTHEW GRAY.
J. FLETCHER MOULTON, F.R.S.
ALEXANDER SIEMENS.
AUGUSTUS STROH.
C. F. VARLEY, F.R.S.

Associates.
Captain J. T. BUCKNILL, R.E.
CHARLES H. B. PATEY.
T. RUSSELL CRAMPTON, M. Inst. C.E.

OFFICERS.

Auditors.
J. WAGSTAFF BLUNDELL, 12, Delahay Street, Westminster, S.W.
FREDERICK C. DANVERS (India Office).

Hon. Treasurer.—EDWARD GRAVES.

Hon. Secretary.—LIEUT.-COL. FRANK BOLTON.

Hon. Solicitors.
Messrs. WILSON, BRISTOWS & CARPMAEL, 1, Copthall Buildings, E.C.

Chairman of the Editing Committee.—PROF. W. E. AYRTON, F.R.S.

Librarian.—ALFRED J. FROST.

Secretary.—F. H. WEBB.

Bankers.
Messrs. COCKS, BIDDULPH & Co., 43, Charing Cross, S.W.

Library and Offices of the Society.
4, The Sanctuary, Westminster, S.W.

LOCAL HONORARY SECRETARIES AND TREASURERS.

JAMES ALLEN, Telegraph Superintendent, Great Southern Railway, Buenos Ayres	ARGENTINE & ORIENTAL DEL URUGUAY REPUBLICS.
Don JOSÉ APARICIO, Representative of the Direct Spanish Telegraph Company, Calle de Fernando VI., Numº 1, Madrid	SPAIN.
JOHN AYLMER, Civil Engineer, 4, Rue de Naples, Paris	FRANCE.
J. M. COLLETTE, Engineer of the Netherlands Telegraphs, The Hague	The NETHERLANDS.
E. C. CRACKNELL, Superintendent of Telegraphs, Sydney	NEW SOUTH WALES.
JAMES DAKERS, Manager, Montreal Telegraph Company, Montreal	CANADA.
Le Commandeur E. D'AMICO, Director-General of the Italian Telegraphs, Rome	ITALY.
FRÉDERIC DELARGE, Engineer of the Belgian Telegraphs, Brussels	BELGIUM.
N. ISPOLATOFF, Director of Telegraphs in St. Petersburg	RUSSIA.
CHARLES LEMON, Ph.D., Superintendent of the New Zealand Telegraphs, Wellington	NEW ZEALAND.
C. L. MADSEN, 49, Norre Sogade, Copenhagen	DENMARK.
SAMUEL W. MCGOWAN, Chief Inspector of Telegraphs and Postal Service, Melbourne	VICTORIA.
C. NIELSEN, Director-General of the Norwegian Telegraphs, Christiania	NORWAY.
J. R. PREECE, Indo-European Government Telegraphs, Shiraz	PERSIA.
E. ROSENBUSCH, A.M. Inst. C.E., Engineer, Mediterranean Extension Telegraph Company, Valetta, Malta	MALTA AND THE MEDITERRANEAN
Dr. WERNER SIEMENS, 94, Markgrafen, Strasse, Berlin	GERMANY.
J. SIVEWRIGHT, M.A., General Manager of Telegraphs, Cape Town, Cape of Good Hope	THE CAPE AND SOUTH AFRICA.
F. G. TEALE (Acting Local Hon. Sec. and Treasr.), Indian Government Telegraphs, Calcutta	INDIA.
CHARLES TODD, C.M.G., Director-General, South Australian Telegraphs, Adelaide	SOUTH AUSTRALIA.
G. G. WARD, Gen. Superintendent of the Direct United States Cable Company, New York	NORTH AMERICA.
WILLIAM WARREN, Superintendent in Tasmania of the Eastern Extension Australasia and China Telegraph Company, George Town	TASMANIA.

JOURNAL

OF THE

SOCIETY OF

Telegraph Engineers and of Electricians.

Vol. XI.	1882.	No. 42.

The One Hundred and Eleventh Ordinary General Meeting of the Society was held on Thursday evening, April 13th, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the previous meeting were read and confirmed, and the names of new candidates announced and suspended.

The SECRETARY announced that since the last meeting donations to the Library had been received from Mr. J. Berly, Member; Mr. W. Ellis, F.R.A.S., Member; Mr. J. Aylmer, Local Hon. Sec., Paris, and from the Honourable Society of Gray's Inn.

A vote of thanks was passed to the donors.

The following paper was then read:—

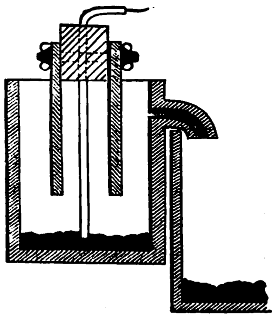
DESCRIPTION OF A FORM OF BATTERY OF LOW INTERNAL RESISTANCE.

By F. HIGGINS, Member.

The battery which I have brought here to-night to introduce to your notice is of the circulating kind, in which the alimentary fluid employed passes from cell to cell by gravitation, and maintains the action of the battery as long as it continues to flow. It cannot, of course, compare with such abundant sources of electricity as dynamo-electric machines driven by steam power, but for purposes in which a current of somewhat greater volume and

constancy than that furnished by the ordinary voltaic batteries is required, it will, I believe, be found in some cases useful. A single fluid is employed, and each cell is provided with an overflow spout.

The cells are arranged upon steps, in order that the liquid may flow from the cell on the topmost step through each successive cell by gravitation [specimen cells were on the table before the audience] to the reservoir at the bottom. The top and the bottom reservoirs are of equal capacity, and are fitted with taps. The topmost tap is used to regulate the flow of the solution, and the bottom one to draw it off. In each cell two carbon plates are suspended above a quantity of fragments of amalgamated zinc. The following is a sectional drawing of the arrangement of the cell :—



A copper wire passes down to the bottom of the cell and makes connection with the mercury: this wire is covered with gutta percha, except where immersed in the mercury. The pores of the carbon plates are filled with paraffin wax. This battery was first employed for the purpose of utilising waste solution from bichromate batteries, a great quantity of which is thrown away before having been completely exhausted. This waste is unavoidable, in consequence of the impossibility of permitting such batteries, when employed for telegraphic purposes, to run until complete exhaustion or reduction of the solutions has been effected, therefore some valuable chemicals have to be sacrificed to ensure constancy in working. The fragments of zinc used in this cell were also the remains of amalgamated zinc plates from the bichromate batteries,

and the mercury which is employed for securing good metallic connection is soon augmented by that remaining after the dissolution of the zinc. It will therefore be seen, that not only the solution, but also the zinc and mercury remnants of bichromate batteries are utilised, and at the same time a considerable quantity of electricity is generated. The cells are seven inches deep and six inches wide, outside, and contain about a quart of solution in addition to the plates. The battery which I employ regularly, consisting of 18 cells, is at present working nine permanent current Morse circuits, which previously required 250 telegraphic Daniell cells to produce the same effect, and is capable of working at least ten times the number of circuits which I have mentioned, but as we do not happen to have any more of such permanent current Morse circuits, we are unable to make all the use possible of the capabilities of the battery. The potential of one cell is from 1·9 to 2 volts with strong solution, and the internal resistance varies from ·108 to ·170 of an ohm with cells of the size described. In order to test the constancy of the battery, a red heat was maintained in a platinum-iridium wire by the current for six weeks both day and night.

The absence or exhaustion of the zinc in any one cell in a battery is indicated by the appearance of a red insoluble chromic salt of mercury, in a finely divided state, floating in the faulty cell. It is then necessary to drop in some pieces of zinc. The state of the zinc supply may also be ascertained at any time by feeling about in the cells with a stick. When not required, the battery may be washed by simply charging the top reservoir with water, and leaving it to circulate in the usual manner, or the solution may be withdrawn from each cell by a siphon. A very small flow of the solution is sufficient to maintain the required current for telegraphic working, but if the flow be stopped altogether for a few hours, no difference is observed in the current, although when the current is required to be maintained in a conductor of a few ohms resistance, as in heating a platinum wire, it is necessary that the circulation be maintained [heating a piece of platinum ribbon]. The battery furnishing the current for producing the effect you now see is of five cells, and as that number is reduced down to

two, you see a glow still appears in the platinum. The platinum strip employed was 5 inches long and ⅛ inch wide, its resistance being 0·42 ohm, cold. That gives an idea of the volume of current flowing. I have twelve electro-magnets in printing instruments joined up on the table, and [joining up the battery] you see that the two cells are sufficient to work them. The twelve electro-magnets are being worked (by the two cells) in mutiple arc at the same time. The current from the cells which heated the platinum wire is amply sufficient to magnetise a Thomson recorder. I have maintained five inches of platinum ribbon in a red hot state for two hours, in order to make sure that the battery I was about to bring before you was in good order. The cost of working such a battery when waste solution cannot be obtained, and it is necessary to use specially prepared bichromate solution, is about 2¼d. per cell per day, with a current constantly active in a Thomson recorder circuit, or a resistance of 1½ ohms per cell, but if only occasionally used, the same quantity of solution will last several weeks.

A comparison of this with another form of constant battery, the Daniell, as used in telegraphy, shows that six of these cells, with a total electro-motive force of 12 volts and an internal resistance of ·84 of an ohm, cannot be replaced by less than 71 batteries of 10 cells each, connected in multiple arc, or for quantity. This result, however large it may appear, is considerably below that which may be obtained when working telegraphic lines. A current of ·02 weber, or ampère, will work an ordinary sounder or direct writing Morse circuit; the cascade battery is capable of working 100 such circuits at the same time, while the combined resistance of that number of lines would not be below that in which it is found that the battery is constant in action.

Objection may be made to the arrangement of the battery on the score of waste of zinc by local action, because of the electro-positive metal being exposed to the chromic liquid; but if the battery be out of action and the circulation stopped, the zinc amalgam is protected by the immobility of the liquid and the formation of a dense layer of sulphate of zinc on its surface. When in action, that effect is neutralised from the fact that carbon in chromic acid is more highly electro-negative than the chromate

of mercury formed upon the zinc amalgam, and which appears to be the cause of the dissolution of the zinc even when amalgamated in the presence of chromic acid. The solution may be repeatedly passed through the battery until the absence of the characteristic warmth of colour of chromic acid indicates its complete exhaustion. During a description before the Society of thermo-electric batteries some time ago, Mr. Preece mentioned that five of the thermopiles which were being tried at the Post Office were doing the work of 2,535 of the battery cells previously employed. Thirty of the cascade cells would have about the same potential as five such thermopiles, but would supply three and a half times the current, and be capable of doing the work of 8,872 cells if employed upon the universal battery system in the same manner as the thermo batteries referred to.

Although this battery will do all that is required for a Thomson recorder or a similar instrument much more cheaply in this country than the tray battery, and with half the number of cells, I do not think it would be the case in distant countries, on account of the difficulty and cost of transport. A solid compound of chromic and sulphuric acids could be manufactured which would overcome this difficulty, if permanent magnetic fields for submarine telegraphic instruments continue to be produced by electric vortices. In conclusion, and to enable comparisons to be made, I may mention that the work this battery is capable of performing is 732,482 foot pounds, at a total cost of 1s. 6d.

TESTS OF INCANDESCENT LAMPS FOR FALL OF RESISTANCE WITH INCREASE OF ELECTROMOTIVE FORCE AND RATIO OF CANDLE-POWER TO WORK DONE ON LAMP.

By Andrew Jamieson (Member), A.M.I.C.E.,

Principal, College of Science and Arts, Glasgow.

The following tests of incandescent lamps were undertaken by the author (merely as a matter of scientific interest), to ascertain, in the first instance, the fall of resistance with a gradually increasing electro-motive force, and, secondly, the ratio of candle-power to units of work spent on the lamp.

During last year he had from time to time tested various lamps in a more or less rough way, principally at Queen Street Station, Glasgow, where Messrs. R. E. Crompton & Co. have daily at work some 50 Swan lamps (fed by a Bürgin machine) for lighting the Goods Depôt of the North British Railway. The vibration caused by the machinery and the frequent passing of locomotives and trains rendered it very difficult to get correct readings, besides which, there was the difficulty of regulating the current from the dynamo to any desired degree, in order to test the lamps with varying electro-motive forces, on account of its being used at the same time for the lamps outside.

On applying to Sir William Thomson, he very kindly placed at the disposal of the author his instruments and batteries, which enabled him to obtain the series tests of Swan's and British Electric Light Company's lamps, as seen in the first part of Table IV.

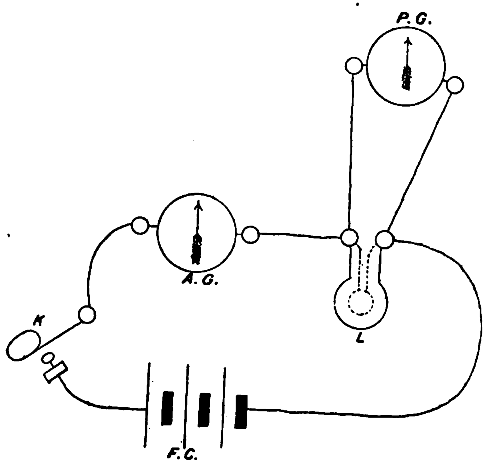
The connections used for taking these tests are shown in the figure on next page.

The lamp was placed at one end of a Rumford's photometer, and a standard candle at the other. The former was joined up in direct circuit with Sir William Thomson's new ampère-meter and any desired number of Faure cells. The two terminals of the lamp were also fixed to the two terminals of Sir William Thomson's potential galvanometer. The galvanometers had been carefully tested shortly before the experiments, and found accurate, and the deflections observed were converted into ampères and volts

respectively by means of tables specially drawn up for use with them.

The potential galvanometer, which has a very high resistance (over 5,000 ohms), gives accurate results extending over a large range, while the ampère-meter has an extremely low resistance. But the deflections on the latter could not be read with any degree

FIG. 1.



Index to Fig. 1.

L, Lamp.
F C, Faure cells.
K, Key.
A G, Ampère Galvanometer (Sir Wm. Thomson).
P G, Potential Galvanometer, or Voltmeter (Sir Wm. Thomson).

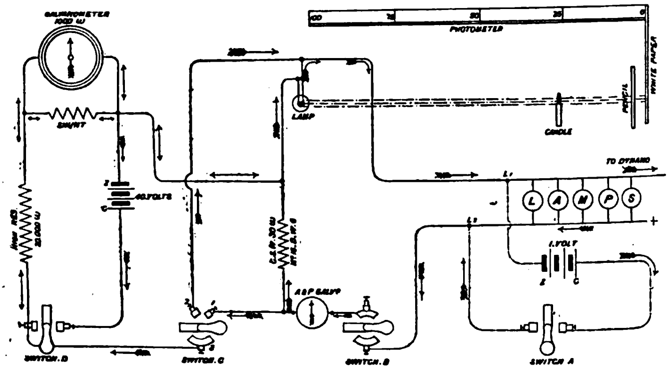
of certainty to less than one-tenth of an ampère (which is near enough for practical purposes), and therefore the resistances might in certain cases be one or two per cent. out, but certainly not more, as will be seen by referring to the tests of the same lamps taken afterwards by a different method.

These instruments of Sir William Thomson's are very easily manipulated, save much calculation, and are so arranged that they may be transported and used, not merely in the laboratory,

but at any electric light installation—in fact, they are "field" instruments.*

Being desirous of extending these tests, and ascertaining the resistances of the carbon filaments over a greater range of electromotive force, the author obtained, through the kindness of Professor Blyth and Mr. M'Kenzie, 50 Grove cells. He arranged them in his laboratory in circuit with the lamp and a fixed constant resistance, according to the plan of connections which he had previously used (in a modified form) at Queen Street Station, and which he found easy of manipulation. (See Fig. 2.)

FIG. 2.



CONNECTIONS USED IN TESTING INCANDESCENT LAMPS.
(Resistance (cold, hot), E.M.F. Current, Candle-power, H.P. per lamp, Candles per H.P., &c.)

Rules for Taking Tests, &c. (*See* Fig. 2.)

(*Resistance Cold.*)—Free dynamo leads, L_1 L_2. Close switches A, B, C (1-3); take deflection D_1. Close switches A, B, C (2-3); take deflection D_2.

$$\therefore D_1 : D_2 :: 30^{\omega} : R.$$

$$\therefore \frac{D_2 \times 30}{D_1} = R \text{ (Resistance cold)}^{\omega}$$

(*Resistance Hot*).—Free switch A; join on dynamo leads, L_1 L_2. Adjust shunt; find D_3 and D_4 by same plan as D_1 and D_2.

---

* They are used in a similar way to the well-known ampère and voltmeter galvanometers of Professors Ayrton and Perry.

$$\therefore D_3 : D_4 :: 30^{\omega} : r \therefore \frac{D_4 \times 30}{D_3} : r \text{ (Res. hot)}^{\omega}.$$

(*Electro-motive Force.*)—Free switches A, B, C; close switch D; take deflection D_5.

$$\therefore D_5 : D_4 :: 40 : E \therefore \frac{D_4 \times 40}{D_5} = E \text{ (E.M.F.) volts.}$$

(*Current per Lamp, Hot*).—Ampères $= \frac{E}{r}$

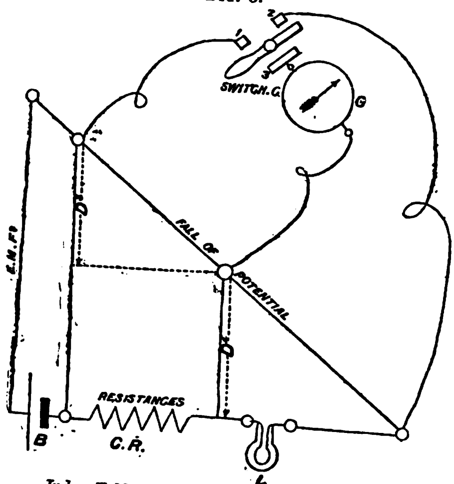
(*Candle-power.*) = K (from comparing with standard candle).

(*Horse-power per Lamp.*) $\frac{E \times C}{746}$

(*Candles per Horse-power.*) $\frac{K \times 746}{E \times C}$

(*Heat-units per Candle in Gramme degrees.*) $\frac{E \times C \times \cdot 24}{K}$.

FIG. 3.



Index Table to Theoretical Diagram (Fig. 2).

L, Lamp.

C R, Constant resistance.

B, Battery, or Dynamo.

G, Galvanometer (dead-beat mirror).

Switch (C).

In these tests (taken on February 25th) the same Rumford's photometer and candle were used as in the former case.

First of all, the resistance in ohms of certain lengths of copper and iron wire (marked G.S.W., Fig. 2) were measured by a Wheatstone bridge, with a view to being afterwards used as constant resistances in circuit with the lamp. There were 7·7 ohms of copper wire, and 48·4 ohms of iron wire, No. 18, B.W.G. The latter was suspended in well-insulated loops in a large hall adjoining the testing-room, in order that the heat generated in it by the current might be free to leave it quickly. (This was found sufficient.) The resistances of the lamps were also taken by bridge with various battery powers from 1 to 5 Daniell cells. Two very carefully-made Daniell cells were got ready (one a large Thomson's tray cell) and compared with each other; they were afterwards used in taking deflection D_5, or, in other words, in finding the value in volts of the galvanometer deflections obtained when testing the lamps by special method (Fig. 2).

The connections having been got ready, a few preliminary trials were made with different resistances of copper and iron wire, the former being placed in position (G.S.W.) and the latter where the lamp is shown. It was found that the deflections D_1 and D_2, obtained from them respectively, gave the correct resistance of the iron wire previously ascertained by bridge. (This proved connections, etc.)

The lamp under test was now placed in the photometer, the current applied, and deflections D_3, D_4, and D_5 noted as quickly as could be done consistent with a very sensitive dead-beat mirror galvanometer, while the candle-power was noted, sometimes by the author and sometimes checked by a second person. All photometric readings taken in this series of tests are marked (S) in the tables (and wall diagrams). Upon comparing these, as well as the resistances and E.M.F.'s obtained previously (see Table IV.), it will be seen that they agree very closely. From three to four minutes sufficed to obtain the three deflections, as well as the corresponding candle-power, but the current was never left on for more than 30 to 40 seconds at one time.

Having worked out these tests and plotted the results, and finding that the resistances and E.M.F.'s formed good continuous curves, but observing certain discrepancies with regard to the

candle-powers, the author applied to Dr. Wallace, who very kindly brought up to the testing-room the whole of his photometric apparatus, consisting of a Bunsen's photometer with a 100-inch bar (with holders for 2 standard candles, etc.), made by Sugg of London. This is the apparatus he uses for testing the city of Glasgow gas.

A fresh series of experiments (detailed in Tables V. to X.) [see Wall Diagram, Table 5, for Swan's lamp No. VI.] was now carried out on March 18th, and continued on the 20th.

Dr. Wallace took the candle-powers with every precaution, while the author confined himself solely to the electrical measurements. He said he had no difficulty in balancing the light given out by the incandescent lamp with that of the two candles, even at 56 candles, which was the highest recorded. He, however, preferred to use a stereoscope for the higher candle-powers, as it aided him in the measurements. The candle-powers which he obtained are marked with a (+) in the diagram of curves, and by a (W) in the tables, and the curves have been plotted through them in order to show more clearly any variations from those recorded by the author. It will be seen that the candle-powers obtained by the Rumford and Bunsen photometers agree very closely at low candle-powers (5 to 25 candles), and this is practically the range of the lamps.

Mr. Tatlock, city analyst, kindly made up some chemically pure mercurous sulphate, with which and the other necessaries, the author made a Latimer Clark cell. Taking the E.M.F. at 1·457 volts, he used it to check the deflections from the two Daniell cells, which had been remade in the same way as before.

In Tables IV. and V. the heat-units per candle in Gramme degrees, as well as the candles per horse-power, are noted.

From an inspection of these columns, a comparison may be made of the relative economy of the different lamps at similar candle-powers, as well as with arc lighting.

The author has not tested arc lights with anything like the same attempt at accuracy as he has incandescent lamps, and therefore he takes the liberty of quoting from Dr. Paget Higg's lecture, delivered before the Institution of Civil Engineers last

February, wherein the latter gives the following data from his own observations :—

Brush (arc)	=	0·1	heat-units per candle.
Siemens ,,	=	0·112	,, ,,
Serrin ,,	=	0·170	,, ,,
Crompton ,,	=	0·120	,, ,,
		4)·502	

Mean, 0·1255 (say) ·125, or $\frac{1}{8}$.

Comparing this with the mean of the five Swan lamps at 8·5 candles, we find they require 1·38 heat-units per candle, or $\left(\frac{1\cdot38}{\cdot125}=\right)$ 11 times as costly as the arc light. Edison's 8-candle and 16-candle lamps are about the same, because he uses the same thickness or area of carbon for each, only the latter is about double the length of the other, and therefore he does not heat his 16-candle lamps to a higher degree than his 8-candle ones. A Maxim lamp at 7·1 candles requires 1·33 heat-units per candle, and is therefore, also, about eleven times as costly as the arc light at that candle-power, but his lamps are issued for 25 candles, and Swan's for 20: it is therefore but fair to compare them with the arc light at these values.

Taking the Maxim as recorded at 24·3 candles, we see that it requires ·71 heat-units, or $\frac{\cdot71}{\cdot125} = 5\cdot6$ times as costly as the arc light; and, taking the mean of the five Swan's at 21·6 candles, requiring ·79 heat-units, we have $\frac{\cdot79}{\cdot125} = 6\cdot3$ times. Against 34 candles, the five Swan's require ·61 heat-units, or $\frac{\cdot61}{\cdot125} = 4\cdot8$ times.

Further examples may easily be obtained from the tables.

These comparisons are very interesting, and can be even better studied by referring to the curves for "ratio of candle-power to units of work," in which the ordinates are candles, and the abscissæ are units of work (E × C); also divided into hundredths of a horse-power.

These figures and curves are not drawn up with a view to solve the question which kind of carbon filament, *i.e.*, bamboo or

parchmentised cotton thread or other kind, has the longest life; they simply afford an interesting study of the candles per horse-power, or units of work which are obtainable from different sizes of carbon filaments. It is quite possible that the same economy might be attained by any one or other of the different systems enumerated, by simply varying the size and form of the filament, but it would require a careful experiment, extending over many thousand hours, in order to thoroughly test and judge the relative efficiency and life of the different forms of carbon filament.

As an interesting instance of what an incandescent lamp can do for a very short time, the author quotes an experiment which he made last year with a Maxim lamp, on which he recorded a light of 660 candles for an expenditure of only 0·147 heat-units per candle, or nearly equal to an arc light. Unfortunately, fine carbon filaments cannot be at present made to stand such combined electric tension and temperature for more than a few minutes. No doubt improvements will be made, and are being made, which give great hopes for power, economy, and durability; and the different manufacturers of incandescent lamps are not only guaranteeing a certain number of candles per horse-power, but a certain length of life for their lamps. Swan's Company informed the author the other day that they have had lamps lighted for over 1,300 hours without giving way.

All makers should mark their lamps with the precise E.M.F. (*not current*) to be used, and carefully select them into lots, so that purchasers may have some certainty of uniformity. Nothing is more tantalising than to find one lamp dull red and the other giving so many candles, or one at the point of giving way and the others quite easy.

The curves for fall of resistance with increased electro-motive force form an interesting study. If a means could be devised of accurately determining the temperatures as well as the resistances and corresponding E.M.F.'s, a coefficient might be arrived at similar to that for the increase in resistance of metals with rise of temperature. The tests and curves, as recorded, show a gradually decreasing resistance from a maximum with ½ volt to a minimum

with from 50 to 80 volts. It will be seen that the carbons fall in resistance about 50 per cent. at 8 candles.

In order to accurately compare these curves, they should all be reduced to one scale with one starting-point, say, 100 ohms (and this is being done for these lamps). In one column of Table V. is shown the candles calculated from the fourth powers of the current, or $K = M\,C^4$, in order to test a law which Dr. Higgs deduced from experiments made by Sir William Thomson and Mr. Bottomley on incandescent lamps. It was, "that the light in an electric system varied as the fourth power of the current, whose resistance or potential was constant, or as the second power of the work in the circuit." It will be seen, however, that neither the resistance nor the potential remains constant for incandescent lamps, for we have the former decreasing and the latter increasing as the candle-power increases.

TABLE IV.

Tests taken at Sir William Thomson's Laboratory with his Potential Galvanometer and Ampère-meter, on February 13th, 1882. Photometer used was constructed on Rumford's plan. (See Fig. 2 for connections.)

SWAN'S LAMPS (old ones).

No. of Lamp.	Res. Cold by Bridge (B).	Res. Hot, Ohms (r).	E.M.F. Volts. (E).	Current in Ampères (C).	Candle-power (K).	Horse-power per Lamp $\left(\frac{E \times c}{746}\right)$	Number of Candles per Horse-power $\left(\frac{K \times 746}{E \times c}\right)$	Heat-units in Gramme degrees per Candle $\left(\frac{E \times c \times \cdot 24}{K}\right)$
I.	64·5	32·5	39	1·2	7·5	·0627	120	...
II.	69	33·9	42	1·24	9	·0698	129	...
III.	65	32·5	39	1·2	8	·0627	128	...
IV.	57·2	30·5	39·7	1·3	9	·0692	130	...
V.	75·2	35·7	41	1·15	9	·0632	143	...
Mean	66·18	33·0	40·14	1·22	8·5	·0655	130	1·38
I.	64·5	31·4	47·1	1·5	23	·0947	243	...
II.	69	33·6	47	1·4	20	·0882	227	...
III.	65	30·4	47·4	1·56	23	·0991	232	...
IV.	57·2	30	48	1·6	21	·1030	200	...
V.	75·2	34·8	48·7	1·4	21	·0914	225	...
Mean	60·18	32	47·6	1·49	21·6	·0953	225	·79

TABLE IV.—(*Continued*).

No. of Lamp.	Res. Cold by Bridge (R).	Res. Hot. Ohms. (r).	E.M.F. Volts. (E.)	Current in Ampères (C).	Candle-power (K).	Horse-power per Lamp $\left(\frac{E \times c}{746}\right)$	Number of Candles per Horse-power $\left(\frac{K \times 746}{E \times c}\right)$	Heat-units in Gramme degrees per Candle $\left(\frac{E \times c \times \cdot 24}{K}\right)$
I.	64·5	29·9	53·8	1·8	40 +	·130	308	...
II.	69	32·	51·2	1·6	31	·110	282	...
III.	65	30	51	1·7	34 +	·116	293	...
IV.	57·2	29·3	51·2	1·75	34 +	·120	283	...
V.	75·2	34·3	51	1·5	31	·103	302	...
Mean	66·18	31·1	51·64	1·67	34 +	·116	293	·61
British Electric Company's.								
1	159	78·2	61	·78	8	·0638	125	...
2	159·7	78·2	61	·78	7	·0638	110	...
3	157·4	74·4	61	·82	11	·0670	164	...
4	159	77·5	62	·8	11	·0650	169	...
5	156·5	74·7	62	·83	12	·0690	174	...
Mean	158·3	76·5	61·4	·80	9·8	·0657	148	1·2
3	157·4	72	72	1	30	·096	311	...
4	159	73	73	1	30	·098	307	...
5	156·5	70	70	1	30	·094	320	...
Mean	157·6	71	71	1	30	·096	313	·57
Tests taken at Queen Street Station and College of Science and Arts, February and March, 1882.								
Edison's 8-Candle Lamps.								
7 B	116	61	51·9	0·85	8·2	·0592	138	1·3
Edison's 16-Candle Lamps.								
Mean of 8 A & 10 A	186	105	97	0·924	15·5	·121	129	1·39
Lane Fox's Lamp.								
1	188	98	66·	·673	8·7	·0596	146	1·22
Maxim's Lamp.								
1	73	39·4	44·2	1·12	7·1	·0665	107	1·33
1	73	39·1	48·9	1·25	14·6	·0820	178	1
1	73	38·2	52·7	1·38	24·3	·0974	249	·71
Arc Lights (by Dr. Paget Higgs). Mean of Four = ·125 Heat-units per Candle.								

TABLE V.

SWAN'S No. VI. (old lamp, glass dull).

Tests of Swan's Lamp No. VI., from which the Accompanying Curves for (1st) *Fall of Resistance and* (2) *Ratio of Candle-power to Work done in Lamp have been plotted, February* 25*th and March* 18*th and* 20*th.*

No. of Experiment.	Res. in Ohms (R to *r*).	E.M.F. in Volts. (E).	Current in Ampères (C).	Units of Work (E × C).	Observed Light in Candles (K).	Calculated Light in Candles.	Heat-units in Gramme degrees per Candle.	Number of Candles per Horse-power.	REMARKS.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	73	·4	·006	...	...	This column shows the number of Candles by calculation, starting with and assuming 20 Candles to be correct; the others are got by the proportion of the 4th powers of their currents in ampères.	$\frac{E \times C \times \cdot 24}{K}$	$\frac{K \times 746}{E \times C}$	All tests taken at Laboratory, College of Science and Arts, Glasgow.
2	71	·9	·013	...	...	$K = m\,c^4$ when $m = 3{\cdot}95$			
3	68	1·4	·021	...	...				
4	66·4	2·3	·035	...	...				
5	61·4	5·3	·07	...	...				
6	55·9	9·7	·17	...	...				
7	54·7	9·8	·18	...	...				
8	50·2	14	·28	...	Dull red		...	...	
9	47·8	17·9	·37	...	...		...	...	
10	44·6	21·5	·48	...	Red		...	...	
11	42·9	24·9	·58	...	...		...	...	
12	41·8	27·2	·65	...	...		...	...	
13	41·5	27·5	·66	...	Bright red		...	...	
14	41·4	28·6	·69	...	...		...	...	
15	40·4	29·6	·73	...	...		...	...	
16	40·3	31·5	·78	...	...		...	...	
17	39	32·4	·83	...	...		...	...	
18	39·3	32·2	·84	...	1 about		...	...	
19	38	37·5	·99	27·5	...		...	...	
20	36·9	41·7	1·13	47·1	4 about	6·4	2·8	63	
21	36·6	43·2	1·17	50·5	6 (W)	7·4	2	89	
22	35·7	45·5	1·27	57·8	8 (S)	10·2	1·7	103	
23	35·8	45·9	1·28	59	9 (B)	10·6	1·57	114	
24	35·6	45·7	1·28	58·5	9 (S)	10·6	1·56	115	
25	35·55	46·2	1·3	60	10 (S)	11·2	1·4	124	
26	35·2	47·9	1·35	64·6	11·8 (W)	13	1·3	136	
27	35·2	48	1·36	65·4	12 (S)	13·5	1·3	137	
28	35	50	1·42	71·4	14 (B)	16·06	1·22	146	
29	34·9	49·7	1·43	71	16 (S)	16·5	1·1	168	* 20 taken as the starting point for obtaining the other figures in same column.
30	34·6	50·8	1·47	74·7	18 (S)	18·4	·99	180	
31	34·8	52·1	1·5	78·1	20 (W)	20*	·94	191	
32	34·2	54·3	1·59	86·3	26·7 (W)	25·2	·78	231	
33	33·8	54	1·6	86·4	25 (S)	25·9	·83	216	
34	33·8	54·7	1·62	88·6	30 (B)	27·2	·7	253	
35	33·4	56·2	1·69	94·6	34 (B) 36·4 (W)	32·3	·64	268	† Doubtful for candle-power, etc.
36	33·3	58·5	1·76	103	41 (B)	37·9	·60	298	
37	33·3	63·3	1·9	120 †	50 (S)	51·5	·58	310	

N.B.—Candles in column K marked (W) were taken by Dr. Wallace, gas analyst for the city of Glasgow, simultaneously with my electrical measurements. He used the *same apparatus and all precautions* with which he tests the illuminating power of gas. Those marked (B) were taken by myself with Dr. Wallace's apparatus on 20th March, and those marked (S) were taken by an ordinary Rumford's shadow photometer on February 25th.

In the last three tests the candle-power appears low. In experiment 35, Dr. Wallace got 36·4 candles against my 34.

TABLE VI.

EDISON 7B (8-candle lamp).

Tests taken at College of Science and Arts, Glasgow, of Edison's Lamp, 7B *(8-Candle Lamp) from which the accompanying curves for Fall of Resistance and Ratio of Candle-power to work done in Lamp have been plotted.—March* 18*th*, 1882.

Number of Experiment.	Res. in Ohms. (R to r).	E.M.F. in Volts (E).	Current in Ampères (C).	Units of Work (E × C).	Candle-power observed (K).
1	115	·5	...	...	...
2	112	2·2	...	...	...
3	105	5·6	...	...	...
4	94·2	10·8	...	...	...
5	86·2	15·6	...	...	...
6	82·1	20	...	...	...
7	77·5	24·6	...	...	...
8	73·4	28·7	...	...	Bright red
9	71·1	32·7	...	...	...
10	68·1	36·1	·53	19	1 (about)
11	66·4	39·7	...	...	...
12	64·7	43·1	...	...	...
13	63·7	45·9	·722	33·1	5·2
14	63·3	46·7	·737	34·4	6·2
15	62·7	48·3	·77	37·1	8·2
16	61	51·9	·85	44·1	12·9
17	60·6	53	·874	46·3	14·3
18	59·3	56·2	·948	53·3	21·3
19	58·4	58	·995	57·7	25·3
20	57·8	61·1	1·06	64·7	35·8
21	57	63·1	1·21	69·8	43·8

N.B.—All Candle-powers were taken by Dr. Wallace, gas analyst for Glasgow, by Bunsen's photometer, in the same way and with the same precautions as he tests the city gas.

TABLE VII.

British Electric Light Company's.

Tests taken at College of Science and Arts, Glasgow, of British Electric Company's Lamp No. 3, from which the accompanying curves for Fall of Resistance and Ratio of Candle-power to work done in Lamp have been plotted.—March 18*th*, 1882.

Number of Experiment.	Res. in Ohms (R to r).	E.M.F. in Volts (E).	Current in Ampères (C).	Units of Work (E × C).	Candle-power observed (K).
	(1)	(2)	(3)	(4)	(5)
1	158	·6	...	...	...
2	154	1·2	...	...	...
3	151	2·7	...	...	...
4	150	2·7	...	...	...
5	134	5·8	...	...	...
6	133	6·7	...	...	...
7	119	10·3	...	...	...
8	110	12·5	...	...	...
9	105	14	...	...	...
10	100	16·1	...	...	...
11	95·2	20·3	...	...	...
12	95	21·7	...	...	...
13	91·7	24·6	...	...	...
14	90·1	26·5	...	...	...
15	88·5	29·3	...	...	...
16	88	30	...	...	Dull red
17	86·8	31·2	...	...	...
18	86	31	...	...	...
19	84·8	33·9	...	...	...
20	84·3	35·4	...	...	Bright red
21	83·3	35·7	...	...	...
22	82·1	38·5	...	...	...
23	81·2	40·4	...	...	...
24	80·7	42	...	...	...
25	79·9	42·6	...	...	...
26	79·6	43·4	·545	23·7	1
27	78·2	46·7	...	...	...
28	77·6	48·3	...	...	2
29	77	50·5	·656	33·1	3·9 (W)
30	76·4	53·6	·70	37·6	5 (S)
31	76·1	54·3	·713	38·7	6·9 (W)
32	75·3	56·7	·754	42·7	8·6 (W)
33	75	57·5	·766	44·1	10 (S)
34	74·5	58·5	·786	46	10·9 (W)
35	74·4	61	·82	50	Low 11 (S)*
36	74·2	61·2	·825	50·6	14·2 (W)
37	74·1	63·5	·857	54·4	16 (S)
38	73·4	63·6	·87	55·3	20·3 (W)
39	73	67	·92	61·6	26·3 (W)
40	72	72	1	72	Low 30 (S)*

(K.) Candles marked (S) were taken by ordinary Rumford's shadow method, and those with (W) after them by Dr. Wallace, by Bunsen's photometer, in the same way as he tests the city of Glasgow gas.

* These two results were taken on February 18th, at Sir Wm. Thomson's laboratory, by myself, and they show a considerable lower candle-power than the other tests for the current and electro-motive force.

TABLE VIII.

SWAN'S No. 1 (old form).

Tests of Swan's Lamp No. 1, from which the accompanying curves for Fall of Resistance and Ratio of Candle-power to work done in Lamp have been plotted. Taken at College of Science and Arts, February 13th and 18th and March 18th and 20th, 1882.

Number of Experiment.	Res. in Ohms (R to r).	E.M.F. in Volts (E).	Current in Ampères (C).	Units of Work (E × C).	Candle-power observed (K).
1	65·5	·4			
2	63	1·7	...	...	...
3	56	4·25	...	...	...
4	50·8	6·4	...	...	...
5	49·5	8·5	...	...	...
6	49·3	7·4	...	...	...
7	47·5	9·3	...	...	...
8	45·2	11·9	·19	...	...
9	44·1	13·3	...	...	...
10	42·1	15·1	·3	...	Dull red
11	41·2	17·8	...	...	...
12	39·7	20·3	·43	...	...
13	38·6	22·5	·51	...	Very bright red
14	38·5	23·6	·59	...	...
15	37·5	25·7	·61	...	...
16	35·7	29	·69	17·6	·5 (S)
17	35	32	·81	...	...
18	34	37·3	·91	29·2	2 (S)
19	32·5	39	1·1	40·9	5·4 (W)
20	33·3	42·2	1·2	46·8	7·5 (S)
21	32	46·5	1·27	53·5	12·5 (W)
22	31·8	46·9	1·45	67·7	22·3 (W)
23	31·4	47·1	1·47	69·2	23·7 (W)
24	31·1	49·4	1·5	70·7	*23 (S)
25	30·9	53·1	1·58	78·4	32·6 (W)
			1·71	91	†55 (W)

Candles with (W) after them, mean that they were taken by Dr. Wallace with Bunsen's photometer, and those with (S) by self with shadow method (Rumford's).

* High. † Low.

TABLE IX.

Lane Fox.

Tests of Lane Fox Lamp No. 1, *from which the accompanying curves for Fall Resistance and Ratio of Candle-power to Work done have been plotted. Take at College of Science and Arts, Glasgow, March* 18*th and* 20*th*, 1882.

Number of Experiment.	Res. in Ohms (R to r).	E.M.F. in Volts (E).	Current in Ampères (C).	Units of Work (E × C).	Candle-power observed (K).
1	188	·6	...	...	...
2	180	3·8	...	...	...
3	165	11·8	...	...	...
4	151	18	...	...	...
6	145	23	...	...	...
7	127·5	33·8	...	...	Red
8	121	38·4	...	...	...
9	117·3	42·1	...	...	...
10	113·4	45·9	...	...	...
11	110	50·3	·456	23	1 (nearly)
12	102	61	·598	36·4	4 (W)
13	101	63	·624	39·4	5·9 (W)
14	98·1	66	·673	44·5	8·7 (W)
15	97·2	69·4	·714	49·5	11·6 (W)
16	95	80	·838	67	*30 (S)

* Taken at Queen Street Station, February 18th, 1882. Lamp fed by Bürgin machine.

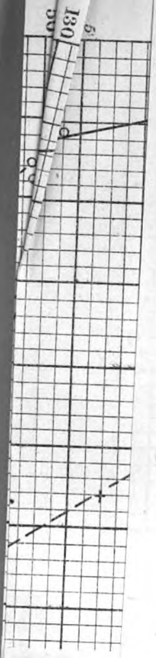
TABLE X.

Maxim.

Tests of Maxim's Lamp No. 1, *from which the accompanying curves for Fall Resistance and Ratio of Candle-power to work done in Lamp have been plott Taken at College of Science and Arts, Glasgow, March* 18*th and* 20*th*, 1882.

Number of Experiment.	Res. in Ohms (R to r).	E.M.F. in Volts. (E).	Current in Ampères (C).	Units of Work (E × C).	Candle-power observed (K).
1	71	1·6	...	...	...
2	67·7	2·8	...	...	...
3	62·7	4·5	...	...	...
4	56·3	8·9	...	...	...
5	50·6	14·4	...	...	...
6	50·2	14·2	...	...	Dull red
7	49·1	16·1	...	...	...
8	47·6	19·7	...	...	...
9	45·7	23·2	...	...	...
10	44·5	26·5	...	...	...
11	43·6	29·5	...	...	...
12	43·2	31·9	...	...	...
13	42·9	32·6	...	...	...
14	42·1	35·1	...	...	...
15	41·5	37·6	...	...	...
16	40·5	42·2	1·04	44	*5·1 (W
17	39·4	44·2	1·12	49·6	7·1 (W
18	39·3	47·4	1·2	57	11·3 (W
19	39·1	48·9	1·25	61·1	14·6 (W
20	38·3	50·4	1·31	66·2	18·5 (W
21	38·2	52·7	1·38	72·7	24·3 (W
22	37·7	55·1	1·46	80·3	33·4 (W
23	37·5	56·6	1·51	85·2	41·7 (W

* Candle-powers marked W were taken by Dr. Wallace in the same way as the o lamps.



Mr. Robert Mansel, shipbuilder, Glasgow, taking an interest in the author's tests, has investigated the relation existing between the observed variables, E, r, and K, on the following physical hypothesis. Heat disappearing in the form of work done, produces physical phenomena which, if properly estimated, are a definite measure of the vanished heat.

It is implied that heat is a definite, but not necessarily a material entity. Heat is viewed as the antecedent and cause of the effects noted; and, in any state of transformation from the ordinary state of association with matter, in which it is usual to name it—*heat*; by a reversal of the conditions, it will return to the original state—electricity, chemical action, or mechanical energy.

When an incandescent lamp, or carbon filament, is inserted in a voltaic circuit; where the electricity is generated by the uniform consumption of, say, zinc in a battery, or equally well by a dynamo-electric machine driven at a uniform rate by a steam-engine, the heat disappearing as estimated by the light in the filament of the lamp (whether as a part of the total amount of the heat due to the chemical action in the battery, or as a portion of the heat disappearing in the steam), has a certain relation to the three variables, viz., electro-motive force, resistance, and candle-power observed, and is expressed by the following equations:—

$$(1)\quad P = E,\ \text{Log.}^{-1}\, a\, r,$$

$$(2)\quad b\, P = K^{\frac{1}{3}}\ \text{Log.}^{-1}\, A\, r,$$

where P = a constant

$$\left.\begin{array}{l} E = \text{E.M.F. in volts observed} \\ r = \text{resistance in ohms observed} \\ K = \text{candles observed} \end{array}\right\} \textit{See } \text{Tables V. to X.}$$

a, b, A = small constant coefficients.

The above formulæ may be stated in a more convenient form for calculation, thus—

$$(1)\quad \text{Log. } P = \text{Log. } E + a\, r,$$

$$(2)\quad \text{Log. } P = \tfrac{1}{3}\ \text{Log. } K + A\, r - \text{Log. } b.$$

In the above, Log.^{-1} means the number whose common logarithm is the product of $a\, r$ or $A\, r$ respectively; (a) and (A) being co-

efficients, which are constant for the same lamp, and (*b*) another coefficient or factor necessary to bring the vanished heat in the second equation to the same unit as in the first. This enables us to compare all the tests of any one lamp; but, for an absolute comparison in heat units, one exact experimental determination would be necessary for each lamp.

To illustrate the manner of obtaining and determining the constants in these equations from the observed data, let us refer to the table of tests on Edison's lamp, No. 7B, Table VI., taking the experiments from Nos. 13 to 21, which include all those in which the incandescence was definitely estimated.

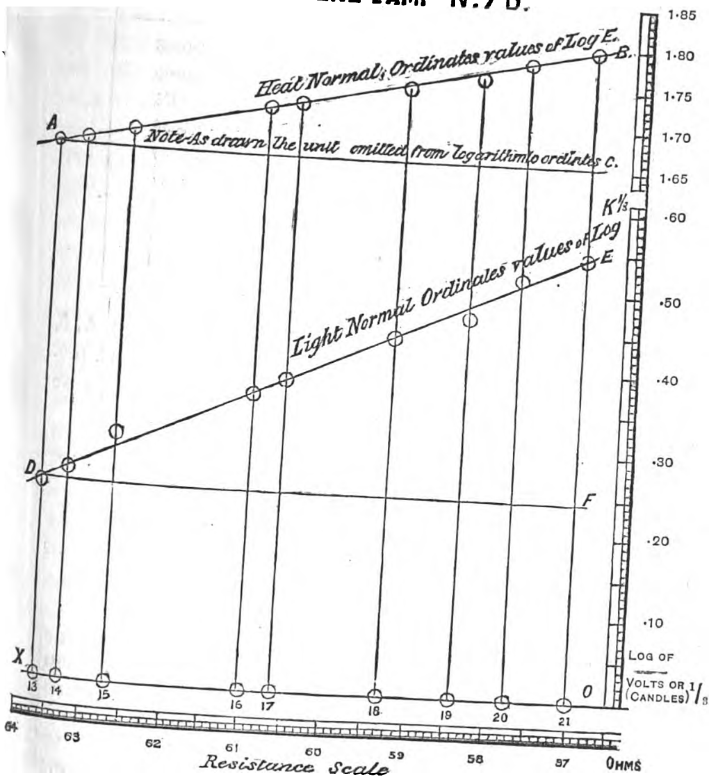
Construction of Figure IV.—On a straight line, O X, as axis, with convenient scale (as figured beneath), mark distances corresponding to the observed resistances, at each of which draw an ordinate equal in length to the common logarithm of the corresponding electro-motive force. A straight line, AB (very approximately), will pass through the ends of all, and will be inclined to the axis at an angle, of which the natural tangent is the (*a*) of equation (1).* Again, on these same ordinates at distances from the axis equal to one-third the length of the logarithm of the incandescence in standard candles, mark points through which, in like manner, the line DE will pass at about twice the inclination of the former line; the natural tangent of this angle is the (A) of equation (2). For distinction, it may be useful to define these straight lines as the *heat normal* and *light normal*, respectively.

Calculation.—Draw the straight lines AC, DF parallel to the axis, then $\frac{BC}{AC} = \tan. a = \cdot 0208$, and $\frac{EF}{DF} = \tan. A = \cdot 045$; with which calculate the values of $(a\, r)$ and $(A\, r)$ for the resistances Nos. 13 to 21. To the first set add the values of the logarithms of the corresponding electro-motive forces, or Log. E; and to the second set, one-third the logarithms of the candle estimates. The first

* The quantities (*a*) and (A) being small, it is convenient to take the unit of the logarithmic ordinates, say, ten times the length of the horizontal unit: this magnifies the inclination to a like extent, and, in any calculation, care must be taken that the horizontal and vertical lines are each measured by its own scale.

will give a set of values of Log. P, the second the values of Log. b P, as given in the second and third columns of the following Table XI. Next; in the fourth column, is noted the values of

FIG. IV. "EDISON'S LAMP No. 7 B."



Log. P, involved in the preceding column, and found from them by substracting from the separate values the average value, Log. b = ·1266; obtained, by subtracting from 3·1122, the average value of Log. b P, the average value, Log. P = 2·9856, given by the second column (or equally satisfactory to the average of the numbers in the fourth column).

TABLE XI.

Particular Values of Log. P (Edison's No. 7B).

Test.	Log. P by Electromotive Force and Resistance.	Log. *b* P by Incandescence and Resistance.	Log. P by Incandescence and Resistance.
No. 13	2·9868	3·1052	2·9786
„ 14	2·9859	3·1126	2·9860
„ 15	2·9881	3·1261	2·9995
„ 16	2·9840	3·1152	2·9886
„ 17	2·9848	3·1121	2·9855
„ 18	2 9831	3·1113	2·9847
„ 19	2·9781	3·0957	2·9691
„ 20	2·9882	3·1190	2·9924
„ 21	2·9856	3·1122	2·9856

These figures warrant us in substituting the values of *a*, A, *b*, and Log. P, thus determined in equations (1) and (2), and proceeding in like manner with the data of the other lamps we derive the following, Table XII.:—

TABLE XII.

General Values of Log. P.

Description of Lamp.	Numerical Relative Value.	By Electro-motive Force and Resistance.	By Incandescence and Resistance.
Edison's No. 7B ...	2·9856	= Log. E + ·0208 *r*	= ⅓ Log. K + ·0450 *r* — ·1266
Swan's No. I.	3·0860	„ + ·0445 *r*	„ + ·0973 *r* — ·4664
Swan's No. VI. ...	2·9760	„ + ·0367 *r*	„ + ·0785 *r* — ·1564
Maxim	3·4556	„ + ·0454 *r*	„ + ·1050 *r* — 1·0219
Lane Fox...........	2·8910	„ + ·0108 *r*	„ + ·0277 *r* — ·1560
British Electric ...	3·8106	„ + ·0273 *r*	„ + ·0548 *r* — ·6274

If the heat and light normals be admitted to be straight lines, these equations only express the necessary and obvious truth, that the *heat* normal carried to the origin, where *r* = *o*, will cut the vertical axis through the origin at a point whose distance from the axis is the value of Log. P; and, in like manner, the *light*

normal will cut this same axis at a point distant from the point Log. P, by the value of Log. *b*. Next, in regard to aberrations from these normals, it should be observed that the nature of the methods by which the electro-motive force, resistance, and incandescence are obtained, are such, that even with experience and care, two observers might register slightly different results; and in the tests here considered, there is the fundamental element, viz., the chemical action in the battery, which certainly has not that which has been assumed for it, the property of absolute constancy, as indicated by certain differences in consecutive tests. The primary fact to notice, is the great influence which these power or heat variations exert upon the incandescence; and although the *light* normal is laid down from the logarithm of the cube root of the candle estimate, we find the aberrations from this normal, as a rule, are double the corresponding sympathetic aberrations from the *heat* normal, showing that, very approximately, the incandescence varies as the sixth power of the electro-motive force. An illustration of this is seen in Fig. IV., No. 19, and in a less degree in No. 15, but a striking illustration is given by the similarly drawn figure data of Swan's lamp No. I. In Fig. V. the electro-motive force logarithms show the upper irregular line; and if on these we now mark off the logarithms of the sixth root of the incandescence, the line through them will correspond almost exactly with the former one; they differ by very nearly a constant length, indicating as the approximate law, $K = \left(\frac{E}{B}\right)^6$; or, Log. K $= 6\{$Log. E $-$ Log. B$\}$; where $B = 27{\cdot}7$.

The candle-powers of this lamp by this formula, compared with the experimental observations, are given in the following table (XIII.); and it will be seen, except the last, that they agree closely; the other apparent exception, No. 23, is inconclusive, inasmuch as it has been estimated by a different method from the adjacent ones, and there is a concurrence of deductions from which to infer, that this observation was underestimated. We might derive the same formula in a more mathematical fashion by doubling the members of equation (1), and then

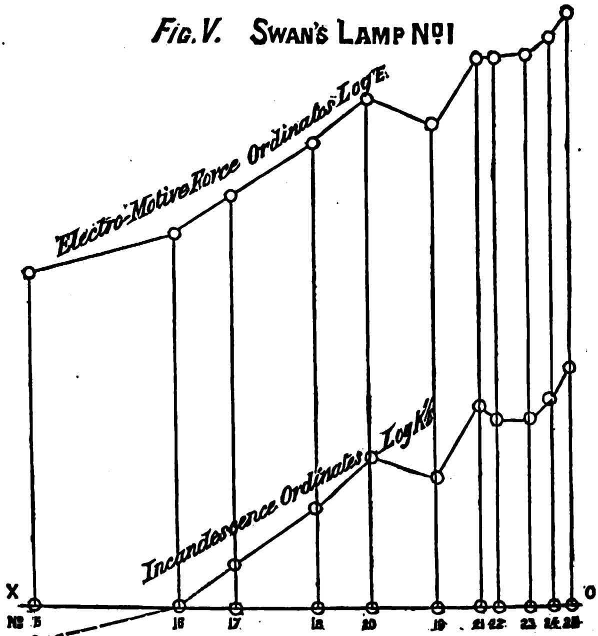
subtracting from them the members of equation (2); then, on the hypothesis, $2\,a = A$; since,

$$(1)\quad 2\ \text{Log. } P = 2\ \text{Log. } E + 2\,a\,r\,;$$
$$(2)\quad \text{Log. } P = \tfrac{1}{3}\ \text{Log. } K + A\,r - \text{Log. } b\,;$$
$$\text{Log. } P - \text{Log. } b = 2\ \text{Log. } E - \tfrac{1}{3}\ \text{Log. } K.$$

Now, let $\text{Log. } P - \text{Log. } b = 2\ \text{Log. } B$,

and we derive $\text{Log. } K = 6\left\{\text{Log. } E - \text{Log. } B\right\}$.

FIG. V. SWAN'S LAMP No. 1



Scales as in Fig. 1.

Note. No. 15 incandescence not observed dotted line the probable

TABLE XIII.

Incandescence, "Swan No. 1." (Standard Candles.)

By Formula, $Log.\ K = 6\ \{Log.\ E - Log.\ 27{\cdot}7\}$

Test.	By Formula.	By Experiment.
No. 15...	·64	·5
" 16...	1·32	?
" 17...	2·38	2·0
" 18...	5·96	5·4
" 19...	7·79	7·5
" 20...	12·50	12·5
" 21...	22·40	22·3
" 22...	23·56	23·7
" 23...	24·72	23·0 ?
" 24...	32·15	32·6
" 25...	49·62	55·0 {Marked High.

In this we make two assumptions, that $2\,a = A$, and that Log. P − Log. b is constant, neither of which are correct, and although there are some simple empirical corrections which might render a formula of this nature fairly accurate, it is best to refer to the normal formula for incandescence, and introduce a correction depending upon the variations of Log. P, after a standard value has been determined: let this correction be denoted by δ Log. P. Then, by formula (1), with the observed values of r and E,

$$\delta\ \text{Log. P} = \text{Log. E} + a\,r - \text{Log. P};$$

formula (2) corrected, then gives

$$\text{Log.}\ b\,\text{P} + 2\,\delta\ \text{Log. P} = \tfrac{1}{3}\ \text{Log. K} + \text{A}\,r,$$

which resolved for K gives

$$\text{Log. K} = 3\left\{\text{Log.}\ b\,\text{P} + 2\,\delta\ \text{Log. P} - \text{A}\,r\right\}.$$

Within the limits of errors of observation, as a rule, this formula is in excellent agreement with the experimental results throughout the whole range of tests, and for each lamp given two good observations, the curves in the author's paper (*see* Plates 1 and 2) could be calculated and drawn. It is, further, a curious fact that these formulæ (1) and (2) are only special cases of a general formula which Mr. Mansel has shown to be the law governing the

relation of power to speed in steam-ships. This general formula is, $P = h\,V\ \text{Log.}^{-1}\ a\,V$, or adapting to logarithms, $\text{Log. } P = \text{Log. } h\,V + a\,V$: in which P represents the power, or, strictly speaking, the heat which disappears from the steam in equivalence of work done; the coefficient (a) corresponds exactly to the (a) for the lamps, and the speed of the vessel V to the resistance r of the lamp: h is another constant involving the dimensions and other elements of the vessel, and so long as the circumstances remain the same, these do not alter. This subject, however, being foreign to the present paper, need not be alluded to further.

All the tests of the lamps were checked by the foregoing formulæ, and *heat* as well as *light* normals were drawn from the latter to a large scale with interesting results and surprising agreement.

Mr. J. E. H. GORDON: A remark I should like to make on this very interesting paper is perhaps rather in the form of a question to Mr. Jamieson. These tests and the amount of candle-power produced by a given horse-power are no doubt extremely important, but, as Mr. Jamieson has said, we in this case have not got any data as to the length of the life of the lamp. Is it not the case that any solid conductor whatever can be made to give any number of candles per horse-power as long as it is not disintegrated by the temperature, and that the amount of candle-power per horse-power is simply a matter of temperature? Therefore it seems hardly fair to the makers of the different lamps if we simply compare the candles per horse-power when they are working at temperatures which are perhaps not the temperatures at which the makers intended their lamps to be used, while at the same time we are not taking into account the probable duration of the lamp.

It seems to me that the important thing to know is, not the efficiency of the lamp at an extreme temperature, but its efficiency at a temperature at which the maker is prepared to guarantee that the lamp shall last for 1,000 hours, and to exchange for a new one if it should break down earlier. The system of testing explained could be applied as well to platinum or iron wire as to

carbon, as long as it is not taken into consideration that either of those substances might break down at any period varying, say, from one minute to six months.

Prof. W. E. AYRTON, F.R.S.: The experiments are of great interest to myself, because I was engaged some short time ago, with Professor Perry, in making a number of similar experiments, with this difference, that we were not concerned with the resistance of the carbon when the lamp was not giving any light. We found, as Mr. Jamieson has found, that for the higher candle-powers the resistance of the carbon does not vary much. For lamps of 10 candle-power there is a resistance of 35 ohms, and in lamps giving 51 candles the resistance falls to 33 ohms. Our results were published in *Engineering* and other papers. For example, a Maxim lamp starting with 178 candles had 23 ohms; at 418 candles the resistance only went down to 21 ohms, and generally there is very little change in the resistance of an incandescent lamp after any appreciable light is reached. Another lamp, which had 23 ohms when giving off 435 candles, fell only to 22·5 when giving off 1,000 candles. Mr. Jamieson has referred to the efficiency of lamps, or the number of candles per horse-power, and we have found that if a Maxim lamp be tested to bordering on breaking, an efficiency equal to from 50 to 75 per cent. of the arc lamp can be obtained. We have got as much as 1,100 candles per horse-power, which was not bad for an incandescent lamp. I refer to the power actually expended in the lamp, not that actually given by the steam-engine to the dynamo. This efficiency of 1,000 candles per horse-power in the Maxim incandescent lamp would be about one-half to three-fourths as good as that obtained with an arc lamp.

I do not quite see Mr. Jamieson's necessity for using the resistance coil he referred to. Possibly it gives greater accuracy; but sufficiently accurate results can be got from taking the two observations of the electro-motive force and current. If you measure with the voltmeter the difference of potential on the two sides of the lamp, and simultaneously with the ammeter the total current flowing through the circuit, then the ratio of the number of volts to the currents in ampères gives the resistance of the lamp; and it is hardly necessary to use a more complicated plan, although

perhaps somewhat greater accuracy may be obtained by introducing the subsidiary coil. But it is difficult to be quite sure what is the resistance of an auxiliary coil when strong currents are passing through it, unless constant measurements of resistance are made with the Wheatstone bridge. A great many errors are liable to be introduced by assuming that the resistance of the coil is anything like the resistance marked on it; even the thick platinum wire resistance coils made by some makers for employment in the electric light have been really abandoned as far as accuracy is concerned, because the wire does not cool with anything like sufficient rapidity, and its resistance has been found to be far greater than that it possessed when only weak currents used in the measurement were passing through.

In our results the Maxim lamps for a low expenditure of power were far, far less efficient than the Swan, ·05 candles as against 8 candles; but that would not show that the Swan was altogether better than the Maxim, because with increase of power the Maxim curve would go up, while the Swan lamp would break. What Mr. Gordon just said is quite to the point—for a certain expenditure of power in two lamps you may say that one lamp is far better than the other; but this conclusion is not a fair one, since the one lamp may be intended for a low power and the other for a high. One might as well say a race-horse was better than a cart-horse, without specifying whether it was the running of a race or the pulling of a cart that the horse was required for. The Swan, for example, was giving, as I have just said, 24 candles, with an expenditure of ·087 horse-power; the Maxim, on the other hand, was only giving one-tenth of that efficiency. The Swan lamp, however, broke at about 32 candles, while the Maxim went up to some 900 candles, so that for high power the Maxim is more efficient than the Swan; and I agree with Mr. Gordon, that the lamps should be tested at about the power the maker intended them to be used at, and not at the same power, unless they be lamps intended to give the same amount of light.

Mr. A. JAMIESON: I have only to say that I undertook the investigation purely as one of scientific interest; and you will find that the candle-powers through which the lamps range in the tables

are from 1 to as high as possible with the electro-motive force at my disposal (one being 56 candles in the case of Swan's lamp No. 1) The Maxim lamp tested would probably not have stood 1,000 candles, as its filament was thin, and therefore its efficiency ran close to the Swans.

This efficiency, as Mr. Gordon remarked, and as I pointed out in the paper, is merely a matter of temperature. If we could only find a coefficient for the *decrease* in the resistance of carbon, with increase of temperature, in a similar way to that in which electricians have ascertained the coefficient for *increase* in resistance of metals, with a similar rise of temperature (such as for copper and platinum) it would be a great matter. If any gentleman could suggest how we could arrive (even approximately) at the actual temperature in degrees of the carbon filament, when it is incandescent, it would be a great step. I cannot conceive very well how it can be done with any degree of accuracy.

The resistance wire to which Professor Ayrton has drawn attention was tested as accurately as possible with an ordinary Wheatstone bridge, and it was carefully insulated and suspended in loops from one end to another of a large hall adjoining the testing-room, and being bare, any slight increase of temperature due to the current passing through it was free to leave it quite readily. The maximum current passed through it never exceeded two ampères, and then only for just sufficient time to take the observations (probably less than a minute). The galvanometer was a dead-beat Thomson, made by White of Glasgow. I have to thank the various gentlemen who kindly gave me lamps to test, as well as those who assisted me in the experiments.

The PRESIDENT: I am sure that when Mr. Higgins and Mr. Jamieson's papers come to be printed in the *Journal* of proceedings, they will be well worthy of being read and studied. As regards Mr. Jamieson's paper, it seems most fortunate that our Society should be the arena where this question of efficiency of incandescent lamps has come to be discussed; and we only hope that this will not be the last paper that Mr. Jamieson will bring before us on the same subject.

The public interest in lighting by means of incandescent lamps

has now increased to an enormous extent, and the whole question of public lighting no doubt is likely to be affected by it. But there is one point that Mr. Jamieson has mentioned this evening which cannot be made too public in connection with this manner of lighting, and that is, that as the candle-power of the incandescent lamp is increased, the number of heat units required approaches that which is necessary for the arc lamp. As that difference decreases so will the application of incandescence become more general and more economical. I will now call upon Colonel Malcolm to propose a vote of thanks to Mr. Higgins and to Mr. Jamieson for their papers.

Colonel G. D. MALCOLM, C.B., R.E.: After an absence of a good many years from this place, where I used hardly ever to miss a meeting, I have very great pleasure in rising in such a full assembly and proposing a vote of thanks to Mr. Higgins and Mr. Jamieson for their two papers. The subjects dealt with are both of them of great interest to me at the present moment. We in the Service are looking out very anxiously for something that shall be constant, and will heat a lot of platinum wire; and it is an intolerable trouble to us to find that nothing is sufficiently constant for our purposes. If Mr. Higgins has solved that problem, he has from the bottom of my heart my most sincere thanks.

As to the question of incandescence and electric lamps generally, I lately left York, and on leaving that town I had a sort of roving commission to see if I could find out how best and most cheaply to light up York Minster. The Dean is very anxious to do it, and if anybody will give us a simple and cheap way of doing it, I think York Minster will be a good advertisement. I beg to propose the vote of thanks.

Prof. W. E. AYRTON: I would suggest that I think Mr. Jamieson could probably supply the answer to his own question as to how to ascertain the temperature of the incandescent carbon filament. He has given such extremely accurate estimates in figures, extending to two places of decimals, that he might go a step further, and by a process of approximation, knowing what the resistance was at a low temperature, arrive at what the high temperature must be from the measurement of the resistance. I have much pleasure in seconding the vote of thanks.

The vote was put and carried unanimously.

A ballot then took place, at which the following were elected, after which the meeting adjourned until the 23rd April, 1882 :—

As Foreign Member:

Thomas Whiteside Rae.

As Members:

Joseph Samuel Beeman.
Prof. J. A. Fleming, B.A., D.Sc.
Frederick Lawrence Rawson.

As Associates:

George William Baskett.
Lieut. Vincent Caillard, R.E.
Lieut. E. Druitt, R.E.
Lieut. Reginald B. Fulford, R.N.
Francis Hernoman Gisborne.
Robert Henry.
J. C. Lamb.
Marshall Herbert Lowe.
Cuninghame Wilson Moore.
F. Morgan.
James Quick.
William Segrave.
Arnold White.

The One Hundred and Twelfth Ordinary General Meeting of the Society was held on Thursday evening, April 27th, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the last meeting were read and confirmed, and the names of new candidates were announced and suspended.

The SECRETARY announced that donations to the Library had been made since the previous meeting by Mr. W. Ellis, Member, Royal Observatory; Col. Bolton, Hon. Sec.; Chevalier de Piccoli, and M. N. Pissarewsky; and a vote of acknowledgement for the favours was accorded.

The following paper was then read:—

ON ATTRACTION AND REPULSION DUE TO SONOROUS VIBRATIONS, AND A COMPARISON OF THE PHENOMENA WITH THOSE OF MAGNETISM.*

By A. STROH.

Magnetism is playing so important a part in every branch of electrical science, and is at the same time a phenomenon so mysterious, and one in connection with which we have yet so much to learn, that the smallest piece of information tending to enlighten us on this subject is of high importance.

The paper that I have the honour to bring before our Society this evening does not deal with electricity, nor even with magnetism in a direct manner, but it deals with certain phenomena so closely resembling magnetism, that I hope a description of them will prove of interest to our members.

I believe that all who have visited the late Paris Exhibition of Electricity agree that one of the most interesting exhibits was in the Norwegian Section, namely, the apparatus illustrative of the experiments of Dr. C. A. Bjerknes, Professor of Mathematical Science at the University of Christiania.

These experiments are a series of hydro-dynamic illustrations of electric and magnetic phenomena, which, although they had

* We are indebted to *Engineering* and the *Electrical Review* for some of the blocks used to illustrate this paper.

been described in Christiania and were brought before the Académie des Sciences, Paris,* appear up to the time of the Exhibition to have been but little known, especially in this country.

Since then several accounts of these interesting experiments have appeared, the best which have come to my notice being those in *La Lumière Electrique*, by M. Frank Geraldy,† and quite recently a very excellent description by Mr. Conrad Cooke, which appeared in *Engineering*.‡

Dr. Bjerknes has obtained, by pulsating drums and oscillating bodies under water, results so analogous with electricity and magnetism as to be perfectly surprising, while the manner in which the experiments were carried out cannot be too highly spoken of. He has shown that not only attraction and repulsion may be obtained in a variety of ways, but that also the lines of force which he obtains, by a most ingenious method, are similar to the lines of force of magnets as indicated by filings in the usual manner.

Dr. Bjerknes has thus started a new mode of investigating the phenomenon of magnetism by comparison, and has opened the road to a new and extensive field of research.

After witnessing these interesting experiments, I could not resist the desire to make similar experiments in other media than water. Air, for instance, seemed especially promising, on account of the facility with which it may be thrown into sonorous vibrations.

After a first hasty experiment I found that much can be done with air in the same direction, and I was soon led on to make a number of experiments, which form the subject of the present paper.

I will now proceed to describe the mode of obtaining *attraction* by sonorous vibrations.

An ordinary harmonium-reed, *a*, Fig. 1, is mounted in any

---

* "Comptes Rendues," Jan., Feb., and July, 1879.

† October 5th, 1881.

‡ Jan. 13th, Feb. 17th, and March 3rd, 1882.

suitable bellows, *b* (the bellows of a toy concertina answer very well), the aperture over which the reed is fixed terminates with a short brass tube, *c*, outside the bellows.

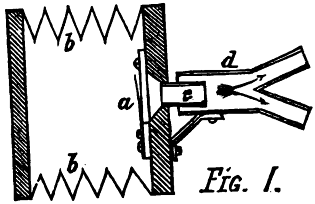


FIG. I.

A larger brass tube, *d*, is fixed at one end to the bellows, so as to partly cover the tube *c*, and to allow an air passage between them, while the other end terminates in two branch tubes or nozzles, on which india-rubber tubes can be placed to communicate with the instrument represented in Fig. 2.

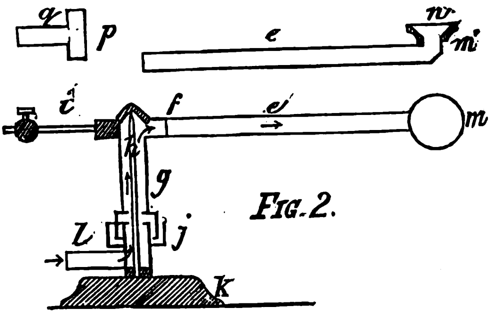


FIG. 2.

This consists of a very light tube, *e*, made of paper, which fits tightly on a nozzle at *f*, so that it may be easily removed and replaced by another. The nozzle at *f* is part of a brass tube, *g*, which at its upper extremity is provided with a cup resting on a steel point, *h*. Opposite the nozzle *f* is a small adjustable weight, *i*, to counterbalance the tube *e* and its attachments.

The lower extremity of tube *g* dips into a mercury cup, *j*, below which is nozzle *l*, for an india-rubber connecting tube. The mercury cup, *j*, and the steel point, *h*, are fixed on a brass stand or foot, *k*.

Inside the lower end of tube *g* is a thin guide-plate (not shown

in diagram), perforated so as not to impede the air passage. This guide-plate is provided with a bearing fitting over the upright steel centre, *h*, thereby preventing the tube from being thrown out of centre. The object of the whole arrangement is to conduct vibrations which may enter the nozzle *l*, through tubes *g* and *e*, without any impediment or loss, while still allowing these tubes to revolve freely on the steel point, *h*.

The extremity of tube *e* is bent at right angles, and carries a little drum, *m*, two and a half centimètres in diameter, of some light wood (shown separately at *m′*), over which is stretched a thin membrane of india-rubber, *n*.

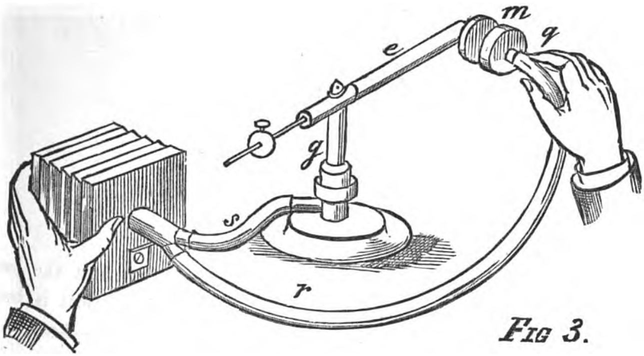


FIG 3.

Another drum of the same dimensions, made of brass, and with a nozzle for an india-rubber connecting tube, is shown at *q*. The membrane, *p*, of this drum is stretched as near as possible with the same tension as the membrane *n*.

The connections by means of india-rubber tubes, *s* and *r*, are made as shown in Fig. 3, and it is necessary that the total length of the tubes *s*, *g*, and *e* is about equal to the length of the tube *r*.

If now pressure is applied to the bellows, the air in passing the reed is thrown into vibrations, which will run along the two passages provided for them—that is to say, each vibration will divide itself between the two tubes *s* and *r*, and the two impulses will arrive simultaneously at the drums, *m* and *q*.

The latter is held by the hand of the operator in the position indicated in Fig. 3, so that its membrane is about one centimètre

distant from that of the other drum, *m*, and it will be found that there is considerable attraction between the two drums, *m* following *q* as the latter is gently withdrawn so long as the vibrations continue.

The number of vibrations per second, or, in other words, the pitch of the note sounded, does not appear to be material, as reeds of different pitch were tried without altering the result obtained.

The experiment may be varied by using the human voice as a source of sound, and a mouth-piece with two branches, as shown in Fig. 4, may be substituted for the bellows and reed.

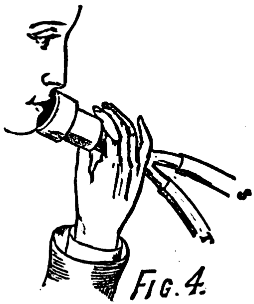


FIG. 4.

Dr. Bjerknes has shown, that to obtain *attraction* the two membranes must vibrate in the *same* phase. This result is best obtained with one and the same source of sound, as above described. But he has also shown, that when the two membranes vibrate in *opposite* phase, *repulsion* takes place.

This cannot well be done with the source of sound above described. One way, however, is, to lengthen one of the branch tubes half a wave length of the sound employed: this should produce opposite phase of the vibrating membrane, but the result is feeble and uncertain.

This difficulty led me to construct an instrument for the production of two sets of vibrations, the phases of which can be changed at will. The instrument is represented in perspective, Fig. 5, and the details of it are shown in Fig. 6.

On a board, A, is mounted a vibrating iron armature, B, similar to that employed in electric house-bells. Its rate of vibration is about 70 per second. (Any other rate would probably do as well.)

The vibrations are maintained by electro-magnets, C C and C′ C′. D and D′ are contact-springs by which, when the armature,

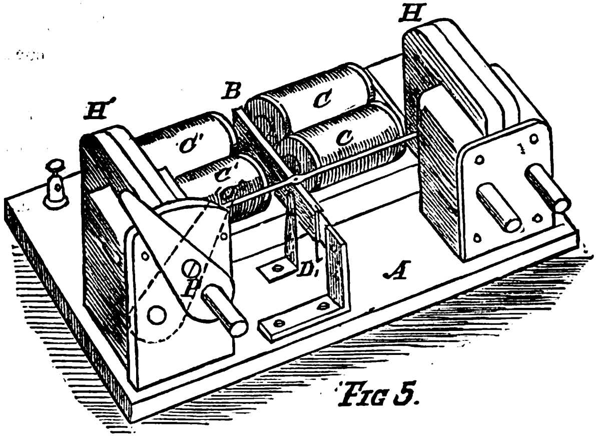


Fig 5.

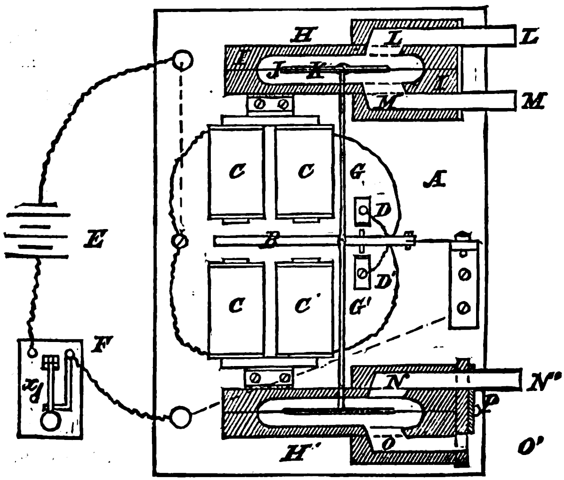


Fig 6.

B, is vibrating, two separate electric circuits are alternately closed, each consisting of one of the two electro-magnets, and a battery of three or four cells, E, so that when the armature, B, makes contact

with the spring D, it is attracted by the magnet C′, and when making contact with spring D′, is attracted by the magnet C.

It is, however, not actually necessary to have two electro-magnets acting on the armature, B, since one electro-magnet and one contact-spring are found sufficient to maintain the vibrations.

F is a contact key, which is convenient for starting and stopping the vibrations. This key has also a little catch, X, which will hold down the handle when desirable.

Connected by a pin with the armature, B, are the rods, G and G′, which communicate with two air pumps, H and H′. The pump H consists of a little box, I, made of two blocks of wood, each hollowed out so that the two form a closed cavity, as shown. This cavity is divided in two by a thin leather diaphragm, which is clamped between the two halves of the box, I. The centre of this diaphragm is strengthened by two discs of cardboard, K, being glued on either side of it; to these is also fixed the end of the rod G, which passes through a small hole of the box, I.

Communicating with the two cavities which are formed by the diaphragm, J, are two air channels, L and M, which terminate in the nozzles, L′ and M′, on which india-rubber connecting tubes can be placed.

The description of pump H answers also for pump H′, except that instead of two nozzles it has only one, N′, which is fixed on a brass lever, P, Fig. 5, which can be shifted so that the nozzle may communicate with either of the two air passages, N and O, according to the position of the lever.

From this arrangement it is obvious that a movement of the armature, B, in the direction of the magnet C will cause air to be expelled from the air passages, L and N, and at the same time air to be sucked in by M and O.

A movement of the armature, B, in the opposite direction will cause a reversal of the movements of the air in the four air passages.

Two india-rubber connecting tubes are placed on the nozzles L′ and N′, leading to the balance and drum (Fig. 2), but since the puffs of air coming from the open nozzles M′ and O′ often interfere with the experiments, it is advisable to place the balance

on a little stand, Q, as shown in Fig. 7, which explains the general arrangement of the apparatus.

The armature, B, is now thrown into vibrations by depressing the handle of the key, F, and at each vibration or movement towards the electro-magnet C, the two pumps will compress the air in both tubes at the same time, and the membranes of the two drums, *m* and *q*, will move outwards or towards each other as in Fig. 8*a*, while movements of the armature towards the

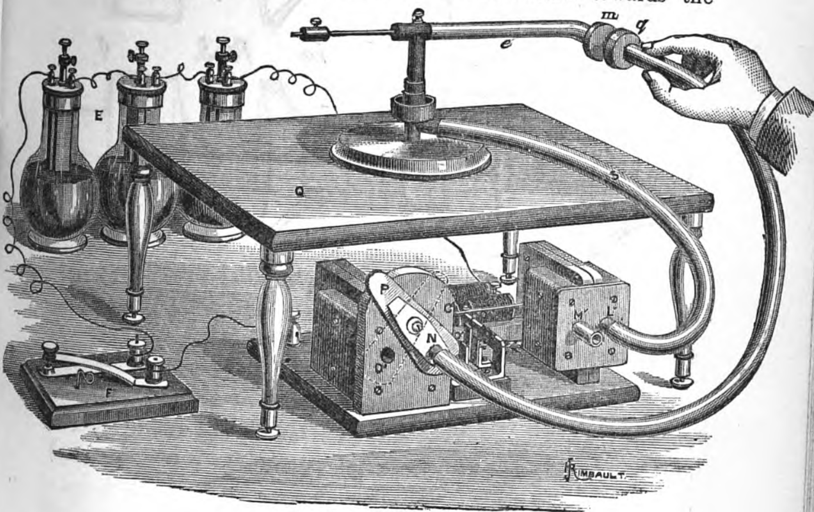


FIG 7.

electro-magnet C will cause the membranes to move inward or to recede from each other, as in Fig. 8*b*, by the air being withdrawn by the pumps.

Under these conditions, *attraction* between the two drums, *m* and *q*, is the result.

If the lever, P, be moved into the position, O″, shown by the dotted lines, then there will be compression in the one tube while there is exhaustion in the other, and one of the membranes is forced outward while the other is drawn inward, as in Fig. 9, *c* and *d*, and in this case there is *repulsion* between the drums, *m* and *q*.

Under favourable circumstances both attraction and repulsion have been obtained at a distance of four centimètres, but the former appears to be generally the stronger.

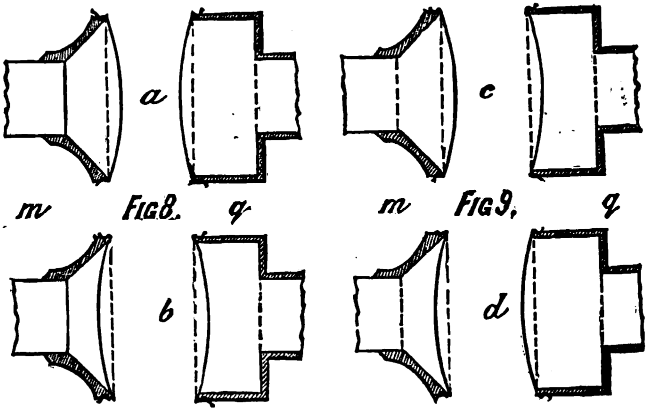


FIG. 8. FIG. 9.

The two membranes as shown in Fig. 8, *a* and *b* (full size), may be said to be vibrating in the *same* phase, while Fig. 9, *c* and *d*, represents them as vibrating in *opposite* phase.

The attraction and repulsion of two magnets resemble the effects above described, with this difference, that with the membranes vibrating in the *same* phase, *attraction* takes place, and in *opposite* phase, *repulsion*, while with *magnets*, *similar* poles *repel*, and *dissimilar* poles *attract* each other.

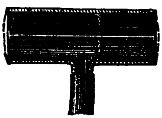


FIG 10.

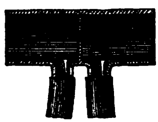


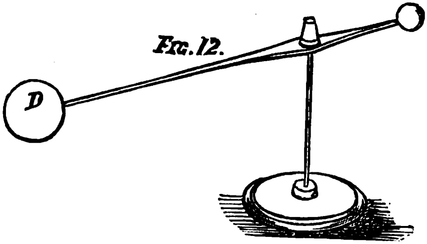
FIG 11.

A drum to imitate a magnet may be made in two ways. For example, Fig. 10 is a drum with a membrane at each end: these are joined together by a light glass rod. A partition, through which the rod passes freely, divides the drum in two compartments, one communicating by a hole with the outer air, and the other by a nozzle and india-rubber tube, *r*, with the pump.

Fig. 11 is also a drum with two membranes, and a partition in the centre, each compartment being provided with a nozzle. Two india-rubber tubes are necessary in this case, and they may be connected with the nozzles M′ and L′, Fig. 7, while the tube *s* may be placed on the nozzle N′.

In both these drums it will be obvious that the membranes must move parallel to each other—that is to say, that when the membrane at one end moves inward, that of the other end must move outward.

Fig. 12.



If either of these drums be presented to the drum *m* of the balance (Fig. 7), while the membranes are in a state of vibration, *attraction* by one end and *repulsion* by the other end, similar to the poles of a magnet being presented to one of a compass needle, is the result.

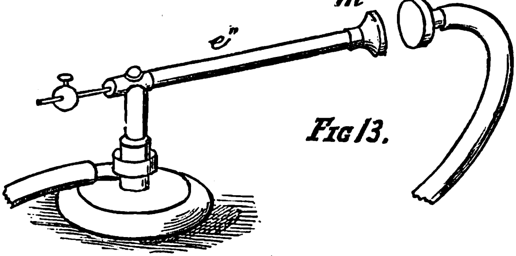


Fig 13.

If instead of the drum *q* (Fig. 7), a piece of paper, cardboard, wood, or even the hand, be brought near the drum *m*, attraction takes place, but in a less degree.

In this case a vibrating membrane attracts a non-vibrating

body, and the effect may be compared to a magnet attracting a piece of soft iron.

This can be further illustrated by one of the double drums, Fig. 10 or 11, being presented to a movable disc, D, Fig. 12, when it will be found that either end of the drum attracts the disc.

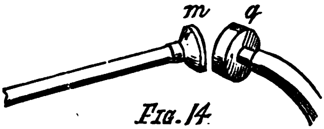


Fig. 14.

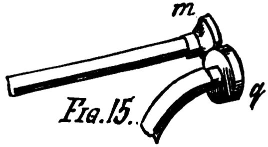


Fig. 15.

The tube e' (Fig. 2), with the bend near the drum, may be replaced by a straight tube, e'' (Fig. 13), having a drum, m', at its extremity. If now the drum q be presented to the drum m, the

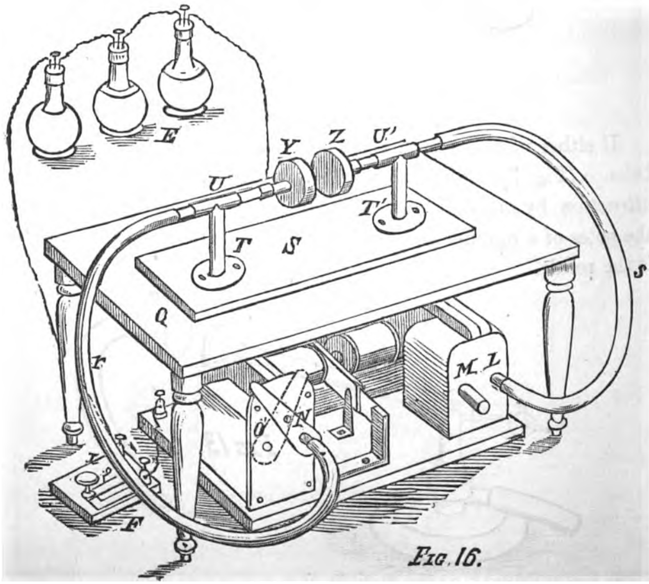


Fig. 16.

latter will place itself exactly opposite to it, as shown in Fig. 13, when the two membranes are vibrating in the *same* phase, and will be repelled from the centre to either side, when the membranes are vibrating in *opposite* phase.

Both attraction and repulsion may be obtained when the drums are in a position as shown in Fig. 14, and even when in such a position as Fig. 15, but in each case to a less degree.

For the next experiments it is requisite that the two drums should be fixed, and therefore the arrangement of apparatus is now slightly altered, and is shown in Fig. 16. It is substantially the same as in Fig. 7, excepting that the balance is replaced by a little board, S, with two brass uprights, T, T′, to support two brass tubes, U and U′. The outer ends of the latter are connected to the india-rubber tubes *r* and *s*, while their inner ends are provided with two drums, Y and Z, similar in construction to the drum *q* in Fig. 2. The membranes of the two drums are facing each other, and the axes of the latter form a straight line.

The two tubes U and U′ are held by friction in the supports T, T′, so that they may be moved when it is desirable to have the two drums nearer together or further apart.

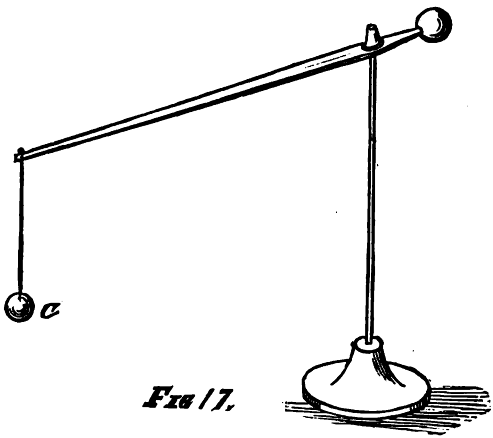


FIG 17.

If between the two drums Y and Z the little cork ball, C, be suspended by a wire to a light beam resting on a needle point, as shown in Fig. 17, it will be attracted and repelled in certain directions.

Fig. 18 is a separate representation of the two drums with their vibrating membranes as seen from above. The lever holding

the cork ball is supposed to be in the direction of line *a b*, so that the ball, when in position 1, can move in the direction of *c* or *d*.

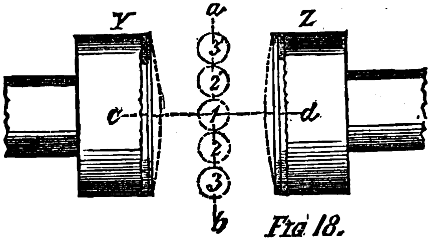


FIG. 18.

Whether now the membranes be set vibrating in the *same* or *opposite* phase, the ball is attracted equally towards each membrane. This is also the case when the ball is shifted to the positions 2 or 3. But if now the needle point and beam supporting the cork ball be placed so that the beam is in the line *c d*, and the ball therefore free to move in the direction of *a* and *b*, it will be found that the ball is attracted in the case of *opposite* phase to the central position marked 1. In the case of *similar* phase the ball is repelled from the central position, 1, and is attracted to the position 3 or 3′.

This experiment is especially interesting on account of the fact to which Dr. Bjerknes has called attention, viz., that two bar-magnets will attract and repel a little pellet of iron placed on a cork floating on the surface of water, in a precisely similar manner.

One of the bar-magnets is placed in the water under the little pellet of iron, the other above, so that they are in a straight line and allow the little pellet to swim between their two poles. When between *dissimilar* poles, the pellet is attracted to the centre; when between *similar* poles, it is repelled from the centre, and comes to rest just outside the poles.

The foregoing experiments are as near as possible analogous with those made by Dr. Bjerknes under water, and possibly all the latter could be repeated under somewhat changed conditions in air and other media. In fact, the experiments of Dr. Bjerknes with pulsating spheres, I have accordingly successfully repeated in air,

but only in a rough way, and only with a view of testing the possibility of their being carried out in air as well as in water.

It is, however, not so much my object in this paper to repeat what Dr. Bjerknes has already so efficiently accomplished, as to draw attention to some interesting effects in connection with these experiments in air, some of which might possibly escape notice when carried out under water. But, before doing so, I propose to branch off at this juncture into an enquiry as to what takes place in the air between and surrounding the two vibrating membranes, and as to what may be the mechanical movements of the air which cause this attraction and repulsion.

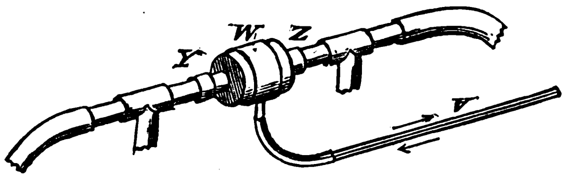


Fig. 19.

With the apparatus as shown in Fig. 16 the following experiments may be made:—Over the two drums Y and Z is placed a short piece of brass tube, W (Fig. 19). This must fit air-tight on both drums, so as to confine the air-space between the two membranes. The tube W communicates by a nozzle and small piece of india-rubber tube with a length of capillary glass tube, V, in which there is a small column of coloured spirits of wine.

If now the two membranes be caused to vibrate for attraction, or in *like* phase, the spirit in the glass tube, after it has recovered from a jump backwards or forwards, occasioned respectively by the membranes commencing their vibrations with a movement *towards* or *from* one another, remains displaced to the extent of one or two millimètres in the direction of the arrow above the tube V. It returns to its original position when the vibrations have been interrupted.

When the membranes vibrate for repulsion, or in *unlike* phase, the spirit column is displaced in the direction of the arrow below the tube.

In the former case, a small quantity of the air in the confined

space is forced into the tube V, while in the latter case air is drawn from the tube towards the confined space. This appears to show that in the first case a *rarefaction*, and in the second a *compression* of the air in the confined space takes place.

A vibrating membrane, surrounded by air, naturally communicates its vibrations to the latter. A forward movement of the membrane causes the air in front of it also to move forward to a certain distance, and a backward movement of the membrane causes the air to follow in that direction.

It may be said, then, that the air is vibrating similarly to the membrane; but, as the former cannot be seen, it is desirable to employ such means as will help to ascertain the direction and amplitude of its vibrations.

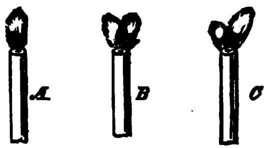


Fig 20.

This is done very efficiently by a little gas jet, of which a full size representation is given in Fig. 20, A. If placed in front of a vibrating membrane, this jet takes, more or less, the form of B, Fig. 20. The little flame follows exactly the vibrations of the air, and, seen from above, its upper and more luminous part forms straight or curved lines of various lengths according to the direction and amplitude of the air vibrations.

If this little flame be moved to different parts near vibrating membranes, or in the vibrating field of a membrane, as it may be called, a very fair estimation is gained of the form which the air vibrations assume; and the three following diagrams have been worked out as carefully as possible from the effects observed in the behaviour of this flame.

Fig. 21 represents the vibrating field created by the vibrations of a *single* membrane; Fig. 22, by two membranes vibrating in the *same*, or *like*, phase; and Fig. 23, by two membranes vibrating in *opposite*, or *unlike*, phase.

The dotted lines in the three diagrams represent the *direction* in which the air particles vibrate; while the double-headed arrows

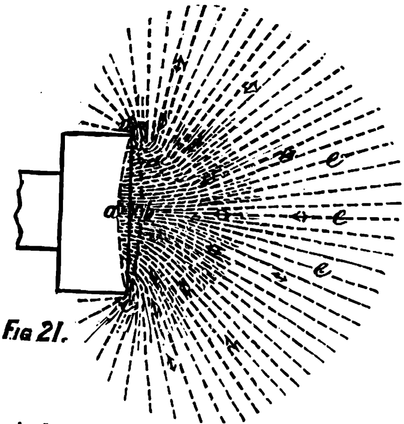


FIG 21.

indicate by their length roughly the *amplitude* of vibration in different parts of the vibrating field.

A

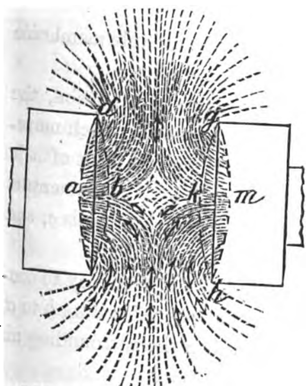


FIG 22. B

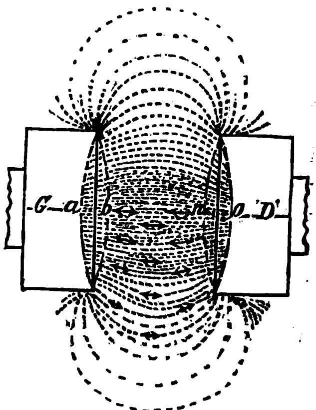


FIG 23.

Each of the three figures must be assumed to represent any section of the vibrating field taken in the plane of the axis of the drums.

In Fig. 23 it may be imagined that there is a cylinder or column

of air vibrating longitudinally, or in the direction of its axis, C D, its greatest amplitude of vibration being in the centre, and the smallest at its circumference. In Fig. 22 it may be said that there is a *disc* of air vibrating radially in the direction A and B, and at right angles to the axis, the greatest amplitude being just within a circle or ring of the same diameter as the drums.

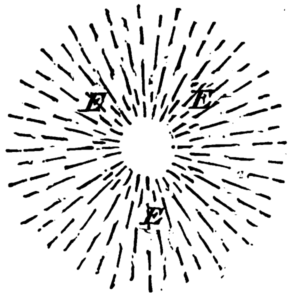


FIG. 24.

Fig. 24 represents roughly these radial vibrations of the imaginary disc of air, looking in the direction of the axis, E being the circle of the greatest amplitude.

The effect produced on the surrounding air by a single membrane (Fig. 21) is probably as follows:—

The membrane is supposed to be in a state of vibration, the limits of which are represented by the lines *a* and *b*. Each movement of the membrane from *a* to *b* propels the air in front of it in the direction of the dotted lines, and imparts to it a momentum which is greatest in the centre of the field from *b* towards *e*, and smallest near *c* and *d*.

The air particles by their momentum have a tendency to continue their movement, but now the membrane recedes from *b* to *a*, and a partial vacuum is thereby formed which the surrounding air tends to neutralise.

Those air particles to which the greatest momentum was given now offer the greatest resistance to the reverse movement, and it is those which had the smallest momentum which are the first to respond and move towards the vacuum. That effect takes place near *c* and *d*.

The particles which had the greatest momentum also partake the return movement, but as this is only after the vacuum has ome partly neutralised by those from the neighbourhood of *c* l *d*, the distance they traverse in returning is less than that versed during their forward movement.

Each air particle, besides vibrating forward and backward, refore suffers permanent displacement by each vibration, so that action resembles that of a pump. In the course of a certain nber of vibrations the air which is drawn inwards near *c* and *d* aused to travel outwards in the direction from *b* to *e*.

In the case of two membranes vibrating in *unlike* phase, as resented in Fig. 23, where repulsion is the result, the one mbrane moves from *a* to *b*, while the other moves at the same ment from *n* to *o*.

During the movement of the first membrane from *a* to *b*, the air propelled towards the second membrane, and the momentum ich the moving air particles thereby acquire is expended partly resisting the return movement as described in the case of the gle membrane.

As soon as the first membrane begins its return movement from *a*, air is drawn towards its centre from near *c* and *d*, and by time this movement is completed the momentum caused by projection of the air from the second membrane's movement 1 *o* to *n* arrives also at *a*.

The first membrane is now ready to begin its movement again *a* to *b*, and has not only to propel the air as before, but also vercome its return momentum, and it thereby suffers a back-l pressure, or recoil, similar to that of a gun when fired.

his effect takes place at each membrane alternately, and the quence is apparent repulsion, when either membrane with um is suspended in the manner shown in Figs. 2 and 7.

he compression of air caused by the momentum of the moving les against each membrane alternately, further results in the shown by the second experiment described in connection Fig. 19.

hen the two membranes are vibrating in *like* phase, as ented by Fig. 22, the first membrane moves from *a* to *b*,

while the second membrane moves from *m* to *k*. A quantity of the air between them is hereby displaced or expelled in the direction of A and B, during which operation the two drums probably suffer a slight recoil, but this is compensated immediately by the partial vacuum formed in the centre in consequence of the momentum of the moving air particles towards A and B.

So far, probably, neither attraction nor repulsion is obtained, but now the two membranes recede from each other: the first moves from *b* to *a*, and the second from *k* to *m*. A partial vacuum is thereby created by both membranes at the *same* time.

The air between *c* and *h*, which by its momentum is still probably at this moment in motion towards B, and that between *d* and *g* towards A, has now to return to neutralise the vacuum between the membranes. This return action *begins* near *c*, *d*, *g*, and *h*, because there the momentum is smallest, and offers the least resistance, and it ends near the line A B, where the momentum is greatest. Here, again, the air particles suffer permanent displacement, since the outward movement towards A and B is greater than the return movement.

During this operation, and until the partial vacuum is neutralised, the air pressure *between* the drums is less than that *outside* the drums, and therefore during that part of each vibration by which vacuum is formed the outer air compels the drums to approach each other when one or the other is suspended as before described, and hence the apparent attraction.

This explanation also accounts for the *first* experiment with Fig. 19, but I will now describe a simple experiment which illustrates these effects in a more striking manner.

Fig. 25 represents two cardboard discs, *a* and *b*, of about fifteen centimètres in diameter. The disc *a* is fixed on an arm, *g*, which can turn freely on a steel upright pin, *f*, and the disc *b* is fixed to a wooden rod which rests loosely in the left hand of the operator, while with the right hand it may be moved to or fro in the direction of the arrows *d* or *e*.

If the two discs be now placed parallel to each other, and about four or five centimètres apart, then by a sudden movement of the right hand in the direction of the arrow *d*, the disc *b* is pushed

towards the disc *a*, but without allowing them to come into contact, the latter, practically speaking, will not be repelled.

The explanation of this singular effect is that during the movement of the disc *b* towards disc *a*, the air between them is forcibly expelled: this operation naturally exerts a pressure upon disc *a*, which yields, however, only to the extent of two or three millimètres, but it also imparts a momentum to the air which causes it to continue its outward course for a moment after the disc *b* has come to rest. A partial vacuum is thereby formed

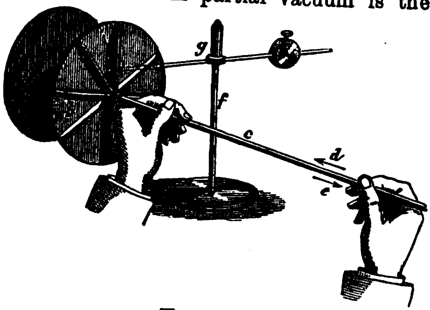


FIG 25.

between the two discs, and this completely overcomes the slight impulse given to disc *a*, for the latter now returns to its original position.

This effect can be still more accurately observed when the rod *c*, instead of being guided by the hands, is mounted in a suitable stand with stops limiting exactly the distance traversed by the disc *b*.

Having ascertained that the disc *b* does not practically repel the disc *a* in moving towards it, it remains now to see what takes place when an equally sudden movement is made in the opposite direction, or that of the arrow *e*. Here the disc *a* follows *b* instantly, on account of a partial vacuum being formed by the separation of the discs.

If now a reciprocating movement be given to the disc *b*, by the right hand moving the rod *c* to and fro in the direction of the arrows *d* and *e*, the disc *a* is *attracted*, and will follow the disc *b* even from a considerable distance.

In this case the partial vacuum formed by momentum as above described is added to that formed by the separation of the two discs, and their combined effects neutralise completely the slight repulsion caused in the first instance by the compression of the air, and leave for the time being a rarefaction of the air between the discs. The air pressure outside the discs, being greater than within, now causes them to approach or apparently to attract each other.

The displacement of air particles from one part of a vibrating field to another, as described above, occasioned by their being sucked from the vicinity of the vibrating membranes towards the centre of the field, and propelled thence along that part of the field where the amplitude of vibration is greatest, is worthy of especial notice.

The first effect here mentioned—that of particles moving towards the centre—is beautifully illustrated by wetting the membrane of a drum (Fig. 26) with a small quantity of water spread equally over the surface. If the membrane be now caused to vibrate, all the water will in a very short time collect in a large drop in the centre, while the membrane becomes perfectly dry near its circumference.

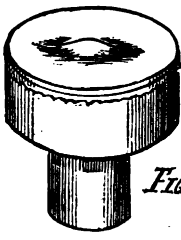


Fig. 26.

The second effect can be observed by placing the little flame before mentioned in the vibrating field, Fig. 22, when it will be found that in the part where the amplitude is greatest the flame assumes the shape of C, Fig. 20, and shows unmistakable signs of being blown in an outward direction.

It may be assumed, therefore, that currents of air are set up in certain directions, and these have been investigated by means of the little windmill shown in Fig. 27, A (actual size).

If this be placed in front of a single vibrating membrane in the places indicated in Fig. 28, it will continue to spin round in the direction shown by the arrows; and if placed between two mem-

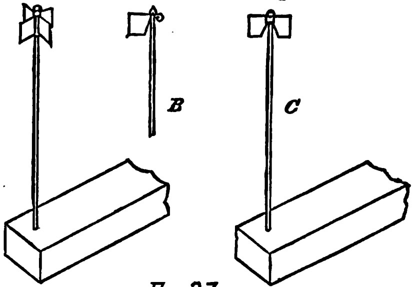
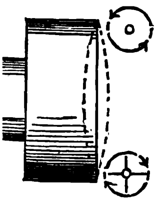


Fig 27.

anes in *like* phase, it will, when in the positions marked 1, 2, 3, 4 ig. 29), turn in the direction shown respectively by arrows.



g 28.

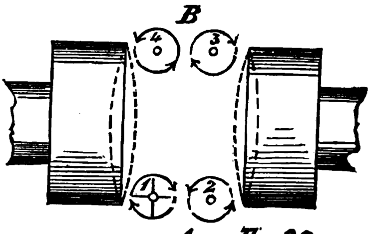


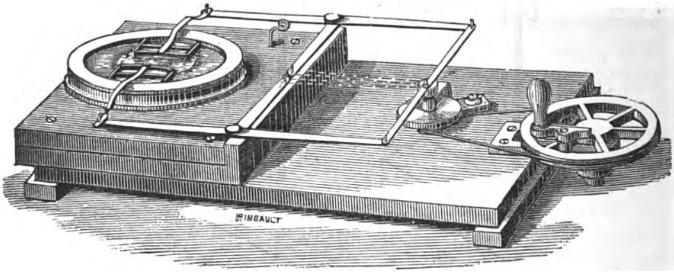
Fig 29.

In the latter case the mill spins more energetically than in the of a single membrane, and indicates that there is a strong ent moving from the centre towards A and B.

It must not be assumed, however, that these currents are inuous: they consist really of a series of backward and forward ements in harmony with the vibrations, each forward motion, ever, being greater than the return motion.

n the case of two membranes in *unlike* phase, these currents, gh strong, are uncertain in their direction. Since all the ting particles have a tendency here to move towards and along central line, the outward current takes probably the weakest of the field, for it is found that generally in one, and some two, of the places indicated in Fig. 29 the current is reversed.

If the amplitude of vibration of one membrane be much greater than that of the other, when the two are still vibrating in *unlike* phase, then the air current near the membrane whose vibrations are strongest is found moving as before, towards the centre, but near



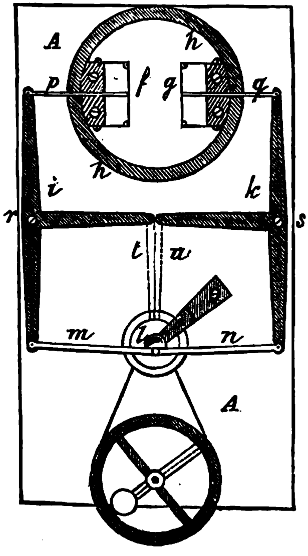


Fig 30.

the other membrane it is reversed. The effect produced by the stronger vibrations here neutralises that of the weaker, and the result is the same as if the less vibrating membranes were not vibrating at all. In such a case there would be no longer repulsion, but attraction.

An instrument which illustrates in a graphical manner some of the phenomena just described is represented in Fig. 30. The object of the apparatus is to imitate the vibrations by mechanical means. On a board, A, is fixed a wooden rim, *h*, and this forms a trough or receptacle for some viscous fluid, such as glycerine. In this trough are mounted two thin steel springs, *f* and *g*, of about one centimètre in width and four in length. They are attached at their extremities to little frames by means of hinges, and represent the vibrating membranes.

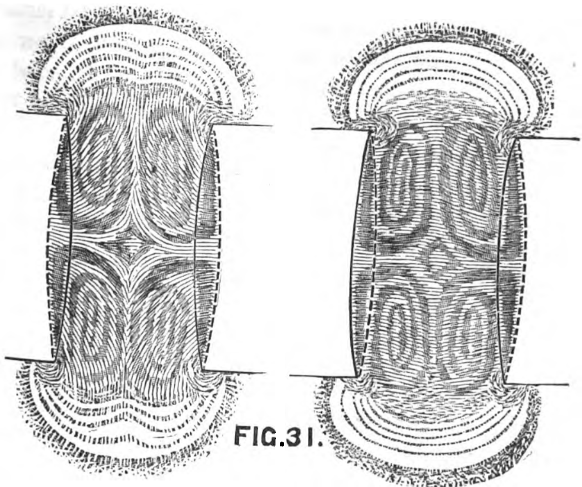


FIG. 31.

To these springs are attached in their centre the rods *p* and *q*, and the latter are acted upon by the levers *i* and *k*, which are centred at *r* and *s*. A little crank, *l*, imparts a reciprocating motion to the levers by means of the crank-rods *m* and *n*. The latter are connected to the levers by pins, so that they may easily be disconnected and placed in the position of the dotted lines *t* and *u*, where also two pins are fixed on the levers for their connection.

When the crank-rods are in position *t* and *u*, and motion is given to the crank, the two steel springs are caused to curve backward and forward, in imitation of two membranes vibrating in *like* phase, while with the rods in position *m* and *n*, *unlike* phase is the result obtained.

If now the trough be filled with glycerine, on the surface of which is placed a light powder, such as licopodium, or what is still better, bronze powder, effects which are represented in Fig. 31 are the result.

Each particle of the powder partakes in the oscillating movement, and through the persistence of vision appears as a short line, the length of which varies with the amplitude of oscillation in different parts of the field.

These results are but an approximate imitation of air vibrations on account of our only dealing in the experiment with a flat surface instead of a circle, and also because glycerine is much slower to take vibration than air. They convey, however, to the mind a perception of the complicated movements of the air between two vibrating membranes.

In Fig. 31, A represents the field in the case of *like* phase, and B in case of *unlike* phase. Besides the direction of vibration or lines of force, both show the current, inasmuch as the deeper shaded parts represent streams of the powder moving slowly from each corner of the field towards the centre, and back again when they meet, to enter again and again their inward course, until at length the effect represented in the diagram becomes obliterated.

Possibly the moving currents of air do not play any important part in the effects produced by vibrations, but are of a secondary character, and probably weaken or strengthen some of the effects only. But it was the investigation of these currents which led to the observation of the following phenomena:—

When using the little windmill (Fig. 27, A) in the way described, it was found that it had a tendency to stop in such a position that two opposite vanes or arms of the windmill were in about the direction of the current, and the other two, as a matter of course, at right angles.

In order to see which pair it was that was being influenced, a double vane, or horizontal windmill, with only two arms standing opposite to each other, was made, Fig. 27, C. When this was placed in different parts of the two vibrating fields, it was found that it would place itself in the positions which are represented

in the two diagrams, Fig. 32, and which will be found in every case to be at right angles to the lines of force.

It was found that a little single vane, Fig. 27, B, which was originally made with a view of ascertaining the direction of air currents, but which it failed to do, would also persist in placing itself at right angles to the lines of force.

The explanation of this phenomenon is probably as follows:—

If in a column of air or liquid (Fig. 33) which is supposed to)e moving in the direction of A to B, an obstruction be placed, ither in the shape of a little disc or the vanes above described, he moving particles of the column have to separate and to alter heir course when they meet the obstruction, in order to pass the

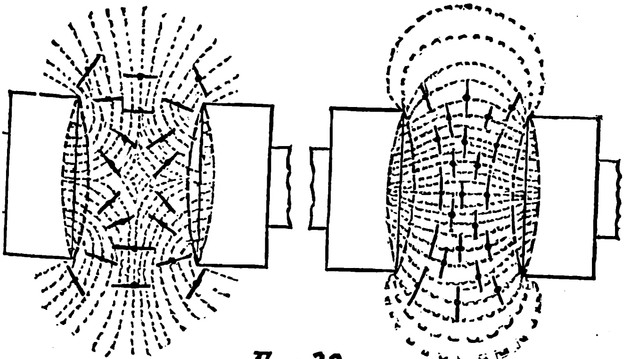


FIG 32.

ıe. When, for instance, a disc which is capable of turning nd a centre at e is in the position shown in the upper diagram, . 33, this separation of particles takes place near a; it is that the force of momentum of the moving particles is prin-lly expended upon the disc, and therefore a movement of the er in the direction of a to b takes place.

As the position of the disc gradually approaches that shown he second diagram, Fig. 33, the point where the separation e column takes place shifts more towards the centre, e, of the and when the latter has finally assumed the position of right es to the column, the pressure due to the diversion of particles ually distributed round the centre, and the pressure near a

is the same as that near *c*. Equilibrium is then established, and the disc comes to rest. This condition is represented in the second diagram, Fig. 33.

If the column of air, instead of only moving in one direction, be now supposed to vibrate, or to perform short movements in the direction of A to B and B to A alternately, then each of the former movements would impart an impulse to the disc at *a*, or between *a* and the centre *e*, while the latter movement would do the same at *d*, or between *d* and *e*, until after a certain number of impulses the disc comes to rest at right angles to the vibrating column.

The case of a single vane, Fig. 27, B, is slightly different. This vane will place itself *parallel* with a column of air, moving in one direction *only*; but in a *vibrating* column it will turn at right angles to the same, as in the case of the double vane.

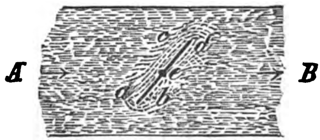
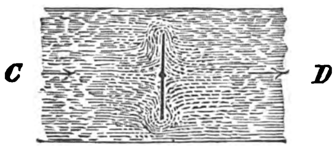


Fig 33.



It may be imagined that the disc or vane, Fig. 33, instead of turning round a centre at *e*, is able to turn on a point near *c d*, while the column is in a state of vibration. At each movement of the column towards B, the vane will receive an impulse near *a*, and by the return movement of the column towards A, another impulse near *d*, as before described; but in this case the impulse near *a* is more effective than that near *d*, on account of the former acting on the longer lever from the centre of motion, and a movement of the vane towards *d* is the result. As the vane moves towards the position of right angles, the leverage near *a* is gradually decreased, while that near *d* is increased, until at last the impulse is given near the centre *e*, on both sides of the vane, and

equilibrium is established when the latter is at right angles to the vibrating column.

In order to compare the results represented by Fig. 32 with the behaviour of a little disc of iron between the poles of magnets, the instrument shown in Fig. 34 was made.

On a board, F, are mounted two cyclindrical electro-magnets, A and B, in such a manner that their poles, *a* and *b*, can be drawn near to or farther apart from each other at will. The diameter of the poles is the same as that of the drums Y and Z, Fig. 16.

By a current reverser, C, which acts on the magnet B, the

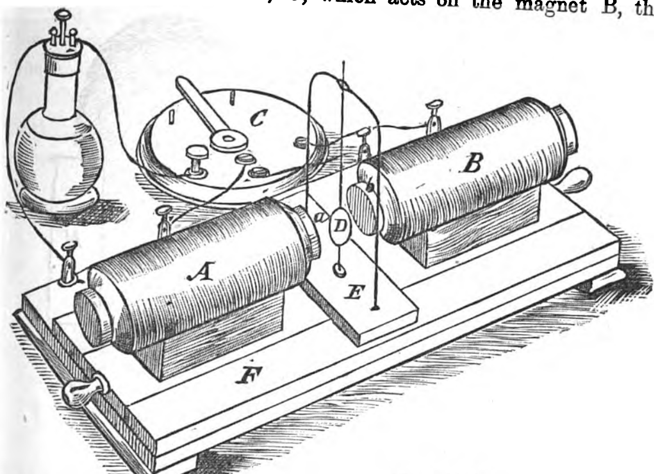


FIG 34.

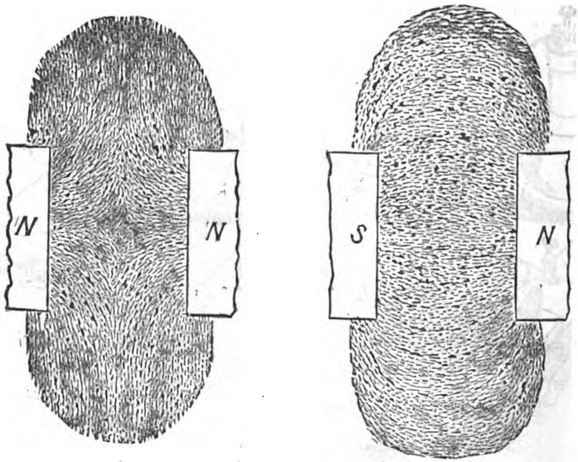
current from one or more cells of a battery, which passes through the coils of both magnets, may be so directed as to make the two poles, *a* and *b*, *similar* or *dissimilar*.

For the purpose of comparison, the lines of force of the magnetic field caused by these magnets were taken by iron filings spread on a piece of cardboard. The latter was cut so as to fit between the two poles, the object being to obtain the lines of force at a plane through their axes. Fig. 35, A and B, represent the two magnetic fields obtained respectively by *similar* and *dissimilar* poles.

It will be observed that on the board F (Fig. 34) is placed a

little instrument consisting of a small stand, or board, E, and a frame supporting a light spindle and iron disc, D. The latter is, in this case, about one centimètre in diameter. This is placed so as to be equidistant from the poles, and so that the spindle of the disc is just outside a line joining the circumference of the poles of the magnets.

If now the two poles be made *similar*, or *both north*, the disc, D, takes up a position at *right angles* to the axis of the magnets, and when these are made *dissimilar*, or *north* and *south*, it turns *parallel* to their axes.



A FIG 35. B

In the first experiment, where the poles are *similar*, they act as *one* pole upon the disc and render it magnetic by induction, so as to both attract its south, and repel its north polarity. In the second experiment, where the poles are *dissimilar*, the disc places itself as near as possible with its opposite poles turned towards those of the magnets. In other words, the disc places itself *parallel* with the lines of force.

The little board, E, with its spindle and disc, D, may now be removed from between the magnets and placed between the two drums Y and Z, Fig. 16, in a similar way. Looking now upon

the membranes of the drums, when vibrating in *like* phase as *similar* poles, and *vice versa*, we now obtain exactly contrary effects to those produced in the case of the magnets. When the two membranes are caused to vibrate in *like* phase, the disc turns *parallel* with their axes, and when in *unlike* phase at *right angles* to it, or, in other words, in each case at *right angles* to the lines of force.

The force which directs the disc, and turns it parallel or at right angles respectively, is not in all parts of the field alike. Between two membranes in *unlike* phase, as well as between two *dissimilar* poles of magnets, the greatest directive force exists in the *centre* or near the axis, while between the membranes in *like* phase, and also between two *similar* poles of magnets, the greatest directive force is near the *circumference* of the drums or the poles respectively. The observation of these effects suggested the following experiment:—

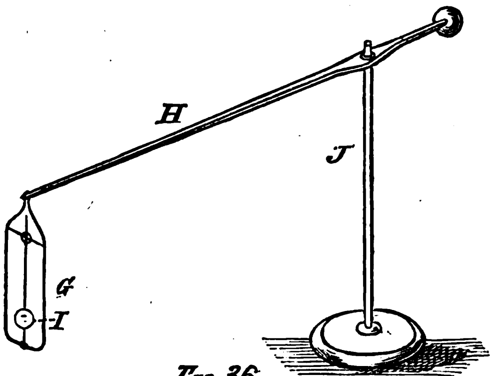
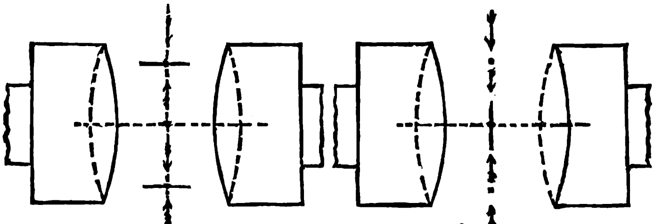


Fig. 36.

A little iron disc, I (Fig. 36), of about eight millimètres in diameter, attached to a delicate spindle, is suspended in a very light frame, G, so that it can turn freely in the latter. The frame, G, is attached to a light beam, H, long enough to reach beyond one of the electro-magnets (Fig. 34), or one of the drums with its tubes (Fig. 16). This beam rests by means of a cup on the needle point, J.

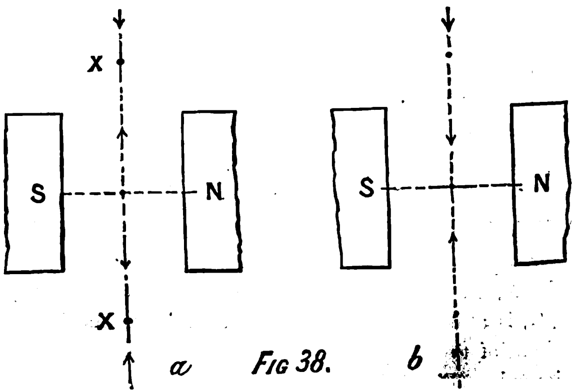
This arrangement may be placed first on the stand, Q (Fig. 16),

so that the beam, H, of the former is in a line parallel with the axis of the drums, and so that the frame G, with its little disc, can pass freely between the membranes of drums Y and Z.



a FIG 37. *b*

When now the membranes are caused to vibrate in *unlike* phase, the disc places itself *central* with, and at *right angles* to their axes, as represented in Fig. 37, *b*; and when the membranes vibrate in *like* phase, the disc places itself *parallel* with their axes, and in that part of the field where the amplitude of vibration is shown to be greatest in Fig. 22, and where the lines of force are at right angles to the axis—that is to say, just within the circumference of the drums, either on one side or the other of their axial line, as shown in Fig. 37, *a*. If thrown out of these positions, it will oscillate for a short time and then resume them.



a FIG 38. *b*

The little apparatus (Fig. 36) may now be placed near the magnetic instrument, Fig. 34, in such a manner that the beam, H,

is over one of the electro-magnets, and so that the little disc, I, with its frame, can play freely between their poles. When these are made *dissimilar*, or *north* and *south*, as in Fig. 38, *b*, the disc is attracted from a distance to the centre or axis of the poles, and places itself in a line with the axis. When the poles are *similar*, or *both north*, the disc is repelled from the centre, and it moves to a position X or X′, Fig. 38, *a*, and at right angles to their axes.

It may be worth noticing the fact that the two positions X and X′, where the disc comes to rest when the poles are similar, is that part of the magnetic field where the lines of force from both poles join to form straight lines at right angles to their axes. (See Fig. 35.)

Were we to assume for the moment that the directive force in both sets of experiments is the result of a similar cause, then the explanation of the positions where the disc comes to rest being farther removed from the axis in the case of the *magnets* than in the case of the *membranes*, may probably be found in the fact that in the latter case the lines of force emanate from the surface of the membranes *only*; while in the case of the magnets the lines of force emanate not only from the face of the *poles*, but also from their *sides*.

By comparing the diagrams Fig. 22 and Fig. 35, A, it appears that the position to which the disc is attracted is in both cases that part of the field where the lines of force unite, and where in the case of a vibrating field the amplitude of vibration is greatest.

The analogy between the two sets of experiments is very striking, but on account of its being inverse it might be assumed that the effects produced by vibrations resemble not *para-magnetism* so much as they resemble *diamagnetism*.

This is, however, not the case, for here again there is a difference. When the little disc of iron (Fig. 36) is replaced by one of bismuth, it turns at right angles to the axis between *dissimilar* poles of magnets. It is true it will do the same between membranes vibrating in *unlike* phase. But it is *repelled* from the centre when between the magnets, while it is *attracted* to the centre by the vibrating membranes.

Comparing, also, the behaviour of a flame between the poles of magnets with that of one between vibrating membranes, the

analogy appears again to be inverse. It is known that a flame between the *dissimilar* poles of a powerful electro-magnet is diverted or repelled from the axis of the poles in a direction at right angles to it. The equivalent effect by vibrations is caused by two membranes vibrating in the *same* or *similar* phase (Fig. 20, *c*).

Although the analogy between magnetism and the effects due to vibrations is inverse throughout, it favours strongly the possibility of magnetism being the result of the vibration of an unknown medium or the ether, as has been suggested by several physicists.

The earliest published experiments on attraction by vibrations were probably those of Professor F. Guthrie,* who, with vibrating tuning-forks, was able to attract non-vibrating bodies, and *vice versa*, and who showed that *two* vibrating forks would attract each other.

I may here mention, that in connection with the experiments described in the early part of this paper, I made numerous trials with two *different* rates of vibrations—that is to say, each membrane of the two drums employed was made to vibrate by a separate reed. These reeds were so constructed that the pitch of the sound produced by either could be gradually raised or lowered through two octaves. Every possible combination of different rates which I could make by this arrangement resulted in *attraction only*. So far as my experiments have gone, it would appear that the *only* conditions on which *repulsion* can be obtained are, that the two sets of vibrations which actuate the two membranes be of *absolutely* the same rate, and that they be in *unlike*, or *opposite*, phase, and this would lead to the assumption that if magnetism be due to the vibration of some medium, the rate of vibration of that medium must be absolutely the same in all magnets. In other words, *one particular rate of vibration of the medium would constitute magnetism.*

Before entering, however, into speculations of this kind, it would undoubtedly be advisable to gather more information; and I would venture to hope that the detail of my experiments, as given in this paper, may induce those who possess the means of making

* *Phil. Mag.*, Nov. 1870.

magnetic and diamagnetic experiments to pursue this new line of research, which, from my own experience, I can promise them they will find to be of high interest, and which may possibly result in solving the problem of what magnetism really is.

I have only to add that my thanks are due to our Secretary, Mr. F. H. Webb, for his able assistance in the preparation of this paper.

Professor F. GUTHRIE said he could not shirk the challenge of the President to make a few remarks, though he came to be instructed rather than to impart ideas to others. He shared with the members present the general feeling of gratitude to Mr. Stroh for his very able and exquisite experiments. He disclaimed the honour attributed to him by Mr. Stroh as to the discovery of the effect of vibration (though the subject had attracted his attention some years ago), which was discovered about 1830 by a little-known French philosopher named Guyot, who was fascinated by the problem of solving the theory of gravitation by the effect of undulations. Mr. Stroh and M. Bjerknes had been apparently chiefly moved by the problem of endeavouring to illustrate, if not to explain, magnetic attraction and repulsion by means of vibrations. It was gratifying that the question had fallen into the hands of so able an experimenter as Mr. Stroh, and it was felt by all that further investigations into the subject could not be in better hands than his. One question which occurred to him during Mr. Stroh's exposition was, whether attraction was replaced by repulsion when the vibrating masses were removed from one another to an additional distance of a half-wave length; or whether, if the vibrating plates were in dissimilar phase, the repulsion was replaced by attraction when the distance between them was extended an integer of a half-wave length. One might suppose that change from attraction to repulsion, and *vice versa,* would take place at the additional half-wave length, just as the interference between two waves produced so-called silence at that distance.

Mr. W. H. PREECE, F.R.S., said that Mr. Stroh had given so much food for thought for many a day in his admirable paper, that he hesitated to make any remarks, and would only suggest

one point which had occurred to him during the reading of the paper. Mr. Stroh had defined the diaphragms to be in similar phase when they were vibrating in opposite directions with respect to a fixed point in the space between them, but a doubt was raised in his mind whether the description of the different phases was strictly correct, for if the vibrating discs, when in so-called similar phase, were superimposed upon each other, they would certainly be in opposite phase. Mr. Stroh would perhaps put him right if he were wrong. This did not in any way alter the results or conclusions he had arrived at, and which added one more step to that ladder which was gradually being formed to bring investigators to the conclusion that magnetic and electric phenomena were, like heat and light, mere motions of matter and of the ether which filled the universe. Dr. Siemens, in a paper read before the Royal Society, had recently endeavoured to show that the interplanetary space was filled with attenuated matter, and thereby threw doubt on the existence of the ether. But the tendency of Mr. Stroh's experiments, and the analogy thereby established between the motion of bodies in air (as Bjerknes had shown in water) and magnetic actions, was to force one to conclude that there must be some hypothetical medium in space which admitted of magnetical and electrical phenomena to take place of a similar kind. He added to the tribute paid by Professor Guthrie to Mr. Stroh, and expressed his admiration of the skill and patience displayed by him in making all so clear, and attributed the success of the experiments to the fact that the entire apparatus was the work of his own hands.

Professor FOSTER, F.R.S., in proposing a vote of thanks to Mr. Stroh, expressed warm admiration, not only of the ingenuity and manipulative skill shewn in the experiments by which the paper was illustrated, but also for the clearness and logical order with which the various points had been brought before the Society. He concluded by saying that Mr. Stroh had given them about the most beautiful experimental lecture he had ever heard.

Professor G. FORBES seconded the vote of thanks, though he was convinced the applause of the members present during the reading of the paper made it unnecessary for him to do more than

briefly explain what had interested him most in the paper they had just heard. When Dr. Guthrie published his experiments on attraction with a tuning fork, some 13 or 14 years ago, many felt that a new world was opened before them, and a sort of expectation existed that the action of gravity, magnetism, or electricity might thereby be explained. Since then the theory had been taken up and laboriously worked out. Bjerknes had worked 25 years on the subject, and his highly interesting results were shown, probably for the first time to many of the members of the Society, at the recent Paris Electrical Exhibition, carried out in such an incompressible substance as water; and it was a matter of the utmost interest to all to see the same phenomena produced in such a highly elastic and viscous substance as air. It was not only the beauty of Mr. Stroh's experiments which elicited the applause given, but the manner in which the experiments were explained. Most of the results hitherto attained had begun by mathematical theory, and were, after a long interval, finally illustrated practically by the experiments of Bjerknes and others. Experiment illustrated the theory. Mr. Stroh had produced the phenomena by experiment, and had explained the results without a single word of mathematics, but by illustrative experiments, which conveyed the truth of the explanations to the senses. Many explanations were perfectly clear when expressed mathematically, but at the same time considerable thought was required to appreciate the validity of the reasoning. Such phenomena could sometimes be explained without an atom of thought: in fact, Von Büch was wont to say that he would not give a fig for a theory which required thought to understand the proofs. So difficult a problem was never more clearly explained than that by Mr. Stroh in his experiments, when he showed why a vibrating body attracts a non-vibrating body in its neighbourhood.

He had heard a whisper that Mr. Stroh intended to suggest that other people ought to work the subject out in future, and that he might leave it safely in their hands. He (Professor Forbes) knew he was expressing the opinion of every one present, when, in seconding the vote of thanks, he conveyed to Mr. Stroh the earnest desire of all that he would, as he had shown himself so competent to do, follow up the subject he had commenced, and which promised such interesting developments.

The PRESIDENT: As the hour is so late, there is not time for Mr. Stroh to answer the questions which have been put to him. I have been asked by more than one member of Council to make a request to Mr. Stroh that, at a future date to be decided upon, he will repeat this lecture and these most interesting experiments before our Society. If Mr. Stroh is able to do so, some of the intervening time may be profitably spent by us in thinking over the subject, and a great many remarks may be thereby drawn from our visitors and members. Mr. Stroh also will have ample time to reply to the questions put to him to-night. I believe that the fame of this lecture will go forth, and if it is repeated we shall have as large a meeting of the Society as has ever been collected together.

A vote of thanks was passed to Mr. Stroh with acclamation.

The meeting then adjourned until Thursday, May 11th, 1882, when it was announced that the following papers would be read:—"Measuring Instruments used in Electric Lighting and in the Transmission of Power," and "The Technical Education of an Electrical Engineer," by Professors W. E. Ayrton, F.R.S, and John Perry, C.E.

ORIGINAL COMMUNICATIONS.

Communicated by W. CROOKES, F.R.S.

REPORT ON THE INCANDESCENT LAMPS EXHIBITED AT THE INTERNATIONAL EXPOSITION OF ELECTRICITY, PARIS, 1881.

Experimental Committee.

GEORGE F. BARKER,
WILLIAM CROOKES,
A. KUNDT,
E. HAGENBACH,
E. MASCART.

To PROFESSOR H. TRESCA,

President of the Experiment-Commission of the Jury of the International Exposition of Electricity.

SIR,

The undersigned, a Sub-Commission appointed to investigate the incandescent lamps of the Exhibition, beg leave to report that they have completed their measurements upon these lamps, and herewith submit the results of their experiments with them.

GEORGE F. BARKER.
WILLIAM CROOKES.

PARIS, *October* 21*st*, 1881.

I.—DESCRIPTION OF THE LAMPS.

The only lamps in the Exhibition which were purely incandescent in character were those of Edison and Maxim, in the United States Section, and those of Swan and Lane-Fox, in that of Great Britain. The idea represented in these lamps is essentially the same in all of them, the differences being, for the most part, details of construction. They all consist of a glass envelope, more or less spherical in form, in which is enclosed a carbon loop, made

of carbonised organic material, and supported upon wires of platinum sealed into the glass. The space in the interior of the lamp is very perfectly exhausted.

A. The Edison Lamp.—The Edison lamp is pear-shaped in form. The carbon filament is long and fine, and is bent into the shape of a U. It is made from Japanese bamboo, cut to the requisite size in a gauge. In section it is nearly square, being about 0·3 millimètre on a side, the ends being left considerably wider. The fibre is carbonised in moulds of nickel, and is attached to the conducting wires by copper, electrolytically deposited upon them.

B. The Swan Lamp.—The Swan lamp is globular in form, the neck being quite long. The carbon filament is made from cotton thread, parchmentised before carbonisation by treatment with strong sulphuric acid. The ends of this filament are very much thickened, and the loop has a double turn at the top. Its ends are clamped in a pair of metal holders, supported laterally by a stem of glass which rises through the neck to the base of the globe. Below, these holders are fastened to wires of platinum which pass through the glass.

C. The Maxim Lamp.—The Maxim lamp is also globular in form, but it has a short neck. Within the neck rises a hollow cylinder of glass, supporting upon its summit a column of blue enamel, through which pass the conducting wires of platinum which carry the carbon. The filament is made from cardboard cut by a punch into the form of an M. In section, therefore, it is rectangular, and several times as broad as it is thick. It is carbonised in a mould through which a current of coal gas is passed. After carbonisation, the filament is placed in an attenuated atmosphere of hydro-carbon vapour, and heated by the current. The vapour is decomposed, and its carbon is precipitated upon the filament. In this way not only are inequalities obliterated, but the resistance of the filaments may be equalised, and brought to any standard required.

D. The Lane-Fox Lamp.—The Lane-Fox lamp is ovoid in shape, the neck being in length intermediate between the two lamps last described. The carbon is in the form of a horse shoe, and is circular in cross-section. It is made from the root of an Italian grass, largely used in France for making brooms. After

carbonisation, the filaments are classified according to their resistances. They are then heated in an atmosphere of coal gas, by which carbon is deposited upon them, as in the filaments of the lamps last described. The filament in the lamp is supported by platinum wires to which it is attached by sleeves of carbon encircling both. These wires pass through tubes in the top of a hollow glass stem. Just below the extremities of these tubes are two small bulbs containing mercury, forming the contact between the platinum wire sealed into the glass above and the copper conductor which enters from below. These conductors are held in place by plaster which fills the base of the lamp.

II.—METHODS OF MEASUREMENT.

The question to be determined was simply the efficiency of these lamps. The efficiency of a lamp is the ratio of energy produced to energy consumed—*i.e.*, the quantity of light given by the lamp for each horse-power of current which it consumes. The data required to calculate this efficiency may be obtained when the electro-motive force of the current, the resistance of the lamp when giving its light, and its illuminating power have been determined.

1. *Electro-motive Force.*—The electro-motive force, or fall of potential through the lamp, was measured by Laws's method. A suitable condenser was charged by being put in communication with a standard Daniell cell, and then discharged through a high resistance galvanometer, the deflection of the needle being noted. This condenser was then connected to the two wires of the lamp, and again discharged through the galvanometer, the deflection being made the same as before by means of a variable shunt connected with the galvanometer. Since with a given condenser the charges it receives are proportional to the potentials of the charging currents, and since the discharge deflections of a galvanometer represent the quantity of these charges, it follows that the electro-motive forces are proportional to these discharge deflections. If, however, as in the present case, the discharge deflections are made equal by means of shunts, then the electromotive forces are proportional to the multiplying power of the shunts.

2. *Resistance.*—The resistance of the lamp, when giving its light, was obtained by making the lamp one side of a Wheatstone's bridge through which the main current was flowing. The second and fourth sides were formed of fixed resistances of known value, and the third side of an adjustable resistance. When the bridge is balanced, the product of the two fixed resistances divided by the adjusted resistance gives the resistance of the lamp at the given candle-power.

3. *Illuminating Power.*—The illuminating power of the lamp was measured on a Bunsen photometer. At one end of the bar was the lamp itself; at the other end two standard candles, placed nearly in line. The plane of the carbon filament was placed at 45° to the length of the bar, and each lamp was measured at 16 and 32 candles.

III.—APPARATUS EMPLOYED.

1. *Condenser.*—The condenser used in these measurements had a capacity of 1 microfarad, divided into sections of 0·4, 0·3, 0·2, and 0·1. The dielectric was paraffined mica, and the brass work was supported on ebonite pillars. Made by Latimer Clark, Muirhead, & Co., London, and exhibited in their section at the Exhibition.

2. *Galvanometer.*—The galvanometer was a Thomson double-coil astatic instrument, enclosed in a square case with glass sides. Measured resistance, 6,550 ohms. Used with lampstand and scale, in the ordinary way. Made by Elliott Brothers, London.

3. *Standard Cell.*—An ordinary Daniell cell, the copper plate being immersed in a saturated solution of pure copper sulphate, contained in the porous cell, and the zinc plate amalgamated, in a saturated solution of pure zinc sulphate, in the outer jar; one of a battery of ten cells forming a part of the Edison exhibit.

4. *Resistance Coils.*—(*a.*) A set of standard coils, measuring from 1 ohm to 5,000 ohms. All other resistances employed were standardised by these. Made by L. Clark, Muirhead, & Co., and a part of their exhibit. (*b.*) A set of coils used in the Wheatstone's bridge. Compared carefully with set (*a*). These coils formed a part of the exhibit of Edison.

5. *Wheatstone's Bridge.*—Four conducting wires of large size

arranged on the table in the form of a rhomb. A test galvanometer was inserted between the obtuse angles of the rhomb, and a pair of shunt wires from the main conductors were attached at the acute angles. The first side of the rhomb contained the lamp to be measured, standing in its place on the photometer. The second side contained a fixed resistance of 5 ohms. The third side contained a variable resistance (Resistance b); and the fourth side a fixed resistance of 950 ohms. This bridge formed a part of the Edison exhibit.

6. *Photometer.*—The photometer employed was of the Bunsen form, having a double bar, 80 inches long, graduated in inches and in candles. The disc was of paraffined paper, with a plain spct in the centre. The disc box was movable on rollers, and contained inclined mirrors to facilitate the adjustment. The candles used were of spermaceti, made by Sugg of London, to burn 120 grains (7·776 grms.) per hour. The entire apparatus was surrounded with heavy black cloth. Also a part of the Edison exhibit.

7. *Dynamo-electric Machine.*—An Edison sixty-light machine was used to furnish the current required. In this machine the field-magnets, which are very long and heavy, stand vertically. The field is maintained by a shunt current, regulated by an adjustable resistance in its circuit. The bobbin is wound on a cylinder like that of Siemens, from which it differs, however, in its details. Its resistance was only 0·03 ohm, and the current delivered, at a speed of 900 revolutions, had an electro-motive force of 110 volts. A part of the Edison exhibit.

IV.—RESISTANCE OF LAMPS COLD.

The resistance of the lamps cold was measured on a Wheatstone's bridge of the ordinary form and in the usual way. The Edison lamps were taken at random from the stock on hand. The Swan lamps were furnished by Mr. Edmunds, the Lane-Fox lamps by Mr. Stewart, and the Maxim lamps by Mr. Lockwood. Twenty-four of each were taken (except the Lane-Fox, of which only fifteen were furnished), and ten selected from these for the tests. The measurements of the Edison and Swan lamps were made by

Mr. E. G. Acheson; those of the Lane-Fox and Maxim lamps by Mr. H. Crookes. The following are the results obtained:—

Number.	Edison.	Swan.	Lane-Fox.	Maxim.
1	237	74	53	73
2	233	50	56	84
3	268	54	56	76
4	260	73	56	74
5	251	55	54	74
6	228	72	50	71
7	227	39	53	68
8	249	67	52	63
9	219	55	57	65
10	237	52	63	73
Mean ...	241	59	55	72

V.—MEASUREMENT OF EFFICIENCY.

1. *Experimental Results.*

A. The Edison Lamp.—In this measurement the entire condenser was employed. When charged with the standard cell and discharged through the galvanometer without shunt, a deflection of 310 scale divisions was obtained, as a mean of ten closely accordant experiments. The photometer readings were made by Mr. Crookes, the bridge readings by Major R. Y. Armstrong, and the galvanometer readings by Prof. G. F. Barker.

(*a.*) *At* 16 *Candles.*

Number of Lamp.	Photometer Reading.	Bridge Reading.	Galvanometer Reading.
1	16—14·75	35—34·5	75
2	16—15	35·0	74
3	16	30·5	74
4	16	32·3	73
5	16—17	33·4	73
6	16—17·5	36 0	73
7	16—15	36·6	78
8	16	34·5	75
9	16—19	37·5	74
10	16	37·7	74

(b.) At 32 Candles.

Number.	Photometer.	Bridge.	Galvanometer.
1	32	37·2	66
2	32	37·2	65
3	32	32·2	66
4	32	34·3	64
5	32	35·2	67
6	32	37·9	69
7	32	38·5	69
8	32	36·3	69
9	32	38·9	69
10	32	38·8	69

B. THE SWAN LAMP.—The entire condenser was used in these measurements also, the deflection being 310 divisions. The photometer was read by Mr. H. Crookes, the bridge by Mr. Crookes, and the galvanometer by Professor Barker.

(a.) At 16 Candles.

Number.	Photometer.	Bridge.	Galvanometer.
1	16	119·5	136
2	16	161·7	145
3	16	148·8	137
4	16	113·5	122
5	16	145·9	134
6	16	122·1	138
7	16	229·0	179
8	16	135·1	145
9	16	159·5	146
10	16	171·0	145

(b.) At 32 Candles.

Number.	Photometer.	Bridge.	Galvanometer.
1	32	123·5	121
2	32	167·2	122
3	32	155·2	121
4	32	116·0	116
5	32	154·7	115
6	32	129·7	120
7	32	237·0	146
8	32	137·5	128
9	32	163·0	127
10	32	175·2	120

C. THE LANE-FOX LAMP.—The entire condenser was employed, and the deflection was the same, 310 divisions. Mr. H. Crookes read the photometer, Mr. Crookes the bridge, and Professor Barker the galvanometer.

(*a*.) *At* 16 *Candles.*

Number.	Photometer.	Bridge.	Galvanometer.
1	16	172·0	150
2	16	168·7	145
3	16	177·6	161
4	16	171·7	157
5	16	171·0	156
6	16	189·5	156
7	16	179·0	156
8	16	181·1	164
9	16	161·7	146
10	16	164·7	148

(*b*.) *At* 32 *Candles.*

Number.	Photometer.	Bridge.	Galvanometer.
1	32	178·7	135
2	32	175·5	129
3	32	181·2	149
4	32	175·2	148
5	32	175·7	143
6	32	192·3	143
7	32	186·2	146
8	32	184·5	146
9	32	167·3	133
10	32	172·0	129

D. THE MAXIM LAMP.—The entire condenser was used, as in the previous cases. But the deflection obtained was 315 divisions, owing probably to the higher temperature of the room. Photometer read by Mr. H. Crookes, bridge by Mr. Crookes, galvanometer by Professor G. F. Barker.

(*a*) *At* 16 *Candles.*

Number.	Photometer.	Bridge.	Galvanometer.
1	16	111·8	115
2	16	111·3	119
3	16	106·2	111
4	16	124·7	120
5	16	111·9	122
6	16	138·5	121
7	16	122·0	122
8	16	115·6	118
9	16	120·6	123
10	16	103·0	111

(*b.*) *At* 32 *Candles.*

Number.	Photometer.	Bridge.	Galvanometer.
1	32	114·6	102
2	32	114·8	106
3	32	109·7	100
4	32	128·6	112
5	32	114·5	112
6	32	140·8	113
7	32	126·9	110
8	32	120·4	105
9	32	126·5	110
10	32	109·7	101

E. The Candle Record.

1. *Edison Lamp.*

Candle-power.	Loss in Grms.	Time in Mins.	Loss per Min.
16 32	18·13 21·22	73 84	0·2483 0·2526
2. *Swan Lamp.*			
16 and 32	34·15	126	0·2695
3. *Lane-Fox Lamp.*			
16 and 32	40·70	153·75	0·2647
4. *Maxim Lamp.*			
16 and 32	26·90	104	0·2586

2. *Methods of Calculation.*

1. *Illuminating Power.*—The standard candle should burn 7·776 grms. spermaceti per hour, or 0·1296 grm. per minute. The two candles used should burn 0·2592 grm. per minute. The corrected candle power of the lamp, therefore, is obtained by the proportion: As 0·2592 is to the amount actually burned per minute, so is the observed candle-power to the corrected candle-power.

2. *Resistance (hot).*—From the theory of the Wheatstone bridge, the resistance of either side is equal to the product of the adjacent sides divided by the opposite side. In the bridge used for the measurement, the resistances in the two adjacent sides were 950 and 5 ohms. Hence by dividing their product, 4,750, by the reading of the variable resistance observed, the resistance of the lamp hot is obtained.

3. *Electro-motive Force.*—In Laws's method the electro-motive forces are proportional to the multiplying power of the shunts employed. Since with the Daniell cell no shunt was used, the multiplying power of the shunt used with the lamp-current represented directly the electro-motive force through the lamp, in terms of the standard cell. The multiplying power of a shunt is the sum of the galvanometer resistance and the shunt resistance, divided by the shunt resistance. In this case the resistance of the galvanometer was 6,550 ohms. Hence if S represent the resistance of the shunt, obtained by experiment, $\frac{6{,}550+S}{S}$ will represent the electro-motive force. Since the electro-motive force of a Daniell cell is not 1 volt, as here assumed, but 1·079 volts, strict accuracy would require the figures given to be increased in that ratio. Moreover, the small error arising from the inductive action of the needle on the galvanometer-coils has been regarded as unimportant.

4. *Current.*—By the law of Ohm the current strength is the quotient of electro-motive force by resistance. Dividing the electro-motive force in volts by the resistance in ohms the current strength is obtained in ampères.

5. *Electrical Energy.*—The work done by a current is proportional to the product of the square of the current-strength into the resistance of the circuit. Or, since the electro-motive force is equal

to the product of the current-strength by the resistance, the energy is represented by the product of the electro-motive force in volts by the current-strength in ampères. This gives the energy in volt-ampères.

6. *Mechanical Energy.*—Since an absolute unit of work is done per second by an absolute unit of electro-motive force in a circuit of one absolute unit of resistance, 1 volt-ampère represents 10^7 absolute units of mechanical work per second, or 0·10192 kilogram-metre. By multiplying the volt-ampères by 0·10192, the product is the mechanical work done in the lamp in kilogram-metres.

7. *Lamps per Horse-power of Current.*—One horse-power is 75 kilogram-metres per second. By dividing 75, therefore, by the number of kilogram-metres of work done in the lamp per second, the quotient is the number of such lamps maintained by a horse-power of current.

8. *Candles per Horse-power of Current.*—The number of candle-lights per horse-power of current is obtained, of course, by multiplying the number of lamps per horse-power of current by the corrected candle-power of each.

9. *Normal Lamps per Horse-power of Current.*—Conversely, by dividing the number of candles per horse-power of current by the normal value of the lamp in standard candles (in the present case 16 or 32), the number of normal lamps per horse-power of current is obtained.

3. *Calculated Results.*

A. The Edison Lamp.

(*a.*) *At 16 Candles.*

No.	Candles (corrected)	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-mètres.	Lamps per Horse-power.	Candles per Horse-power.
1	14·73	136·7	88·33	0·646	57·08	5·819	12·88	189·8
2	14·85	135·7	89·51	0·660	59·05	6·020	12·46	185·0
3	15·33	155·7	89·51	0·575	51·46	5·246	14·29	219·1
4	15·33	147·3	90·73	0·616	55·88	5·697	13·16	201·8
5	15·81	142·2	90·73	0·638	57·88	5·901	12·71	200·8
6	16·04	132·0	90·73	0·687	62·36	6·357	11·80	189·3
7	14·85	129·8	84·97	0·655	55·63	5·671	13·22	205·0
8	15·33	137·7	88·33	0·641	56·67	5·777	12·98	199·0
9	16·76	126·6	89·51	0·707	63·29	6·453	11·62	194·9
10	15·33	126·0	89·51	0·710	63·45	6·469	11·60	177·7

A. The Edison Lamp.

(b.) *At* 32 *Candles.*

No.	Candles (corrected)	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-mètres.	Lamps per Horse-power.	Candles per Horse-power.
1	31·11	127·7	100·20	0·785	78·70	8.023	9·35	291·0
2	31·11	127·7	101·80	0·797	81·11	8·269	9·07	282·2
3	31·11	147·5	100·20	0·679	68·12	6·945	10·80	333·7
4	31·11	138·5	103·30	0·746	77·12	7·862	9·54	296·8
5	31·11	134·9	98·76	0·732	72·28	7·369	10·18	316·6
6	31·11	125·3	95·93	0·765	73·42	7·486	10·02	311·7
7	31·11	123·4	95·93	0·778	74·59	7·604	9·86	306·9
8	31·11	130·8	95·93	0·733	70·32	7·169	10·46	325·4
9	31·11	122·1	95·93	0·786	75·36	7·683	9·76	303·7
10	31·11	122·4	95·93	0·784	75·17	7·633	9·79	304·5

B. The Swan Lamp.

(a.) *At* 16 *Candles.*

No.	Candles (corrected)	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-mètres.	Lamps per Horse-power.	Candles per Horse-power.
1	16·61	39·75	49·16	1·237	60·80	6·199	12·10	200·9
2	16·61	29·38	46·17	1·536	72·57	7·399	10·14	168.3
3	16·61	31·92	48·81	1·529	74·63	7·609	9·86	163·7
4	16·61	41·85	54·69	1·307	71·47	7·286	10·29	170·9
5	16·61	32·56	49·88	1·532	76·42	7·791	9·63	159·8
6	16·61	38·90	48·47	1·246	60·38	6·155	12·18	202·3
7	16·61	20·74	37·59	1·812	68·13	6·946	10·80	179·3
8	16·61	35·16	46·17	1·313	60·64	6·182	12·13	201·5
9	16·61	29·78	45·86	1·540	70·62	7·201	10·41	173·0
10	16·61	27·78	46·17	1·662	76·75	8·824	9·59	159·5

B. The Swan Lamp.

(b.) *At* 32 *Candles.*

No.	Candles (corrected)	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-mètres.	Lamps per Horse-power.	Candles per Horse-power.
1	33·21	39·36	55·13	1·401	77·23	7·87	9·526	316·4
2	33·21	28·41	54·69	1·925	105·30	10·73	6·988	232·1
3	33·21	30·61	55·13	1·801	99·31	10·12	7·407	246·0
4	33·21	40·95	57·47	1·403	80·64	8·22	9·122	302·9
5	33·21	30·71	57·96	1·888	109·40	11·15	6·725	223·3
6	33·21	36·62	55·58	1·514	84·36	8·60	8·720	289·6
7	33·21	20·09	45·86	2·288	104·90	10·70	7·010	232·5
8	33·21	34·54	52·17	1·510	78·79	8·03	9·337	310·1
9	33·21	29·14	52·57	1·804	94·85	9·67	7·756	257·6
10	33·21	27·11	55·58	2·050	114·00	11·62	6·456	214·4

C. The Lane-Fox Lamp.

(a.) At 16 Candles.

No.	Candles (corrected)	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-mètres.	Lamps per Horse-power.	Candles per Horse-power.
1	16·36	27·62	44·65	1·617	72·25	7·365	10·18	166·6
2	16·36	28·16	46·17	1·640	75·72	7·719	9·72	158·9
3	16·36	26·75	41·68	1·559	64·96	6·623	11·33	185·2
4	16·26	27·66	42·72	1·544	65·97	6·726	11·15	182·4
5	16·36	27·78	42·99	1·548	66·52	6·782	11·06	180·9
6	16·36	25·07	42·99	1·715	73·72	7·516	9·98	163·2
7	16·36	26·54	42·99	1·620	69·64	7·100	10·56	172·8
8	16·36	26·23	40·94	1·561	63·90	6·515	11·51	188·3
9	16·36	29·37	45·86	1·561	71·60	7·300	10·27	168·1
10	16·36	28·85	45·26	1·569	71·02	7·240	10·36	169·4

C. The Lane-Fox Lamp.

(b.) At 32 Candles.

No.	Candles (corrected)	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-metres.	Lamps per Horse-power.	Candles per Horse-power.
1	32·71	26·58	49·52	1·863	92·25	9·405	7·98	260·9
2	32·71	27·07	51·78	1·913	99·04	10·100	7·43	243·0
3	32·71	26·09	44·96	1·723	77·47	7·898	9·50	310·7
4	32·71	27·11	45·26	1·669	75·56	7·702	9·74	318·6
5	32·71	27·04	46·80	1·731	81·03	8·261	9·08	297·1
6	32·71	24·70	46·80	1·895	88·69	9·042	8·30	271·4
7	32·71	25·51	49·16	1·927	94·74	9·659	7·77	254·0
8	32·71	25·75	45·86	1·781	81·70	8·330	9·00	294·6
9	32·71	28·39	50·25	1·770	88·93	9·066	8·27	270·7
10	32·71	27·62	51·78	1·875	97·07	9·896	7·58	247·9

D. The Maxim Lamp.

(a.) At 16 Candles.

No.	Candles (corrected)	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-mètres.	Lamps per Horse-power.	Candles per Horse-power.
1	15·96	42·49	57·96	1·364	79·06	8·060	9·305	148·5
2	15·96	42·68	56·04	1·313	73·59	7·503	9·996	159·6
3	15·96	44·73	60·01	1·342	80·51	8·208	9·137	145·9
4	15·96	38·09	55·58	1·459	81·11	8·269	9·070	144·8
5	15·96	42·45	54·69	1·288	70·46	7·183	10·440	166·7
6	15·96	35·10	55·13	1·571	86·61	8·830	8·494	135·6
7	15·96	38·94	54·69	1·405	78·62	7·832	9·577	152·9
8	15·96	41·09	56·51	1·375	77·71	7·923	9·466	151·1
9	15·96	39·39	54·25	1·377	74·73	7·619	9·844	157·2
10	15·96	46·12	60·01	1·301	78·09	7·961	9·421	150·4

D. The Maxim Lamp.

(b.) At 32 Candles.

No.	Candles.	Ohms.	Volts.	Ampères.	Volt-Ampères.	Kilogram-mètres.	Lamps per Horse-power.	Candles per Horse-power.
1	31·93	41·45	65·22	1·573	105·00	10·710	7·006	223·7
2	31·93	41·34	62·79	1·519	95·38	9·724	7·713	246·3
3	31·93	43·30	66·50	1·536	102·10	10·410	7·203	230·0
4	31·93	36·94	59·48	1·610	95·79	9·766	7·680	245·2
5	31·93	41·49	59·48	1·434	85·29	8·695	8·625	275·4
6	31·93	33·74	58·96	1·743	103·00	10·510	7·138	227·9
7	31·93	37·43	60·54	1·617	97·93	9·984	7·512	239·8
8	31·93	39·45	63·38	1·607	101·80	10·380	7·225	230·7
9	31·93	37·55	60·54	1·612	97·62	9·954	7·536	240·6
10	31·93	43·30	65·85	1·521	100·20	10·210	7·346	234·5

4. *Summary of Results.*

(a.) At 16 Candles.

	Edison.	Swan.	Lane-Fox.	Maxim.
Candles	15·38	16·61	16·36	15·96
Ohms	137·4	32·78	27·40	41·11
Volts	89·11	47·30	43·63	56·49
Ampères	0·651	1·471	1·593	1·380
Volt-Amperes	57·98	69·24	69·53	78·05
Kilogram-metres	5·911	7·059	7·089	7·939
Lamps per horse-power... ...	12·73	10·71	10·61	9·48
Candles per horse-power ...	196·4	177·92	173·58	151·27
Lamps of 16 candles per horse-power	12·28	11·12	10·85	9·45

(b.) At 32 Candles.

	Edison.	Swan.	Lane-Fox.	Maxim.
Candles	31·11	33·21	32·71	31·93
Ohms	130·03	31·75	26·[illegible]9	39·60
Volts	98·39	54·21	48·22	62·27
Ampères	0·7585	1·758	1·815	1·578
Volt-Ampères	74·62	94·88	87·65	98·41
Kilogram-metres	7·604	9·67	8·936	10·03
Lamps per horse-power... ...	9·88	7·90	8·47	7·50
Candles per horse-power ...	307·25	262·49	276·89	239·41
Lamps of 32 candles per horse-power	9·60	8·20	8·65	7·48

VI.—CONCLUSIONS.

The following conclusions seem to be sustained by the results which have now been given :—

1st.—The maximum efficiency of incandescent lamps in the present state of the subject, and within the experimental limits of this investigation, cannot be assumed to exceed 300 candle-lights per horse-power of current.

2nd.—The economy of all lamps of this kind is greater at high than at low incandescence.

3rd.—The economy of light-production is greater in high resistance lamps than in those of low resistance, thus agreeing with the economy of distribution.

4th.—The relative efficiency of the four lamps examined, expressed in Carcel burners of 7·4 spermaceti candles each, produced by one horse-power of current, is as follows :—(A.) At 16 candles: Edison, 26·5 ; Swan, 24 ; Lane-Fox, 23·5 ; and Maxim, 20·4. (B.) At 32 candles: Edison, 41·5 ; Lane-Fox, 37·4 ; Swan, 35·5 ; and Maxim, 32·4. To double the light given by these lamps the current-energy was increased, for the Maxim and Lane-Fox lamps, 26 per cent ; for the Edison lamp, 28 per cent ; and for the Swan lamp, 37 per cent.

SHUNTS IN CONNECTION WITH CONDENSERS.

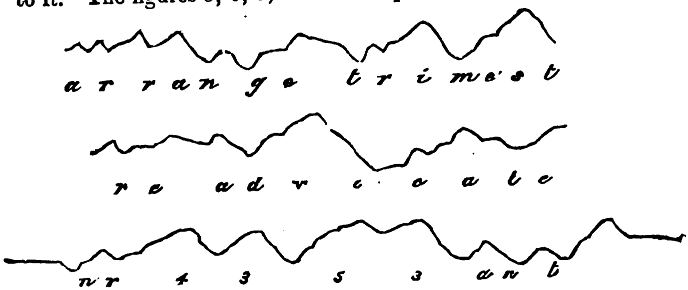
By W. F. Nosworthy, Member.

From observations I have recently had the opportunity of making, at various cable stations, it has struck me how little Shunts seem to be appreciated, or used, in connection with condensers at the receiving end of the cable.

It is well known to all engaged in submarine telegraphy, that if a series of signals in the same direction be sent through a long cable, the spot of light, or siphon (as the case may be), at the receiving end, moves further and further from zero, as each impulse arrives. This effect will be noticed on the attached slip marked "A."

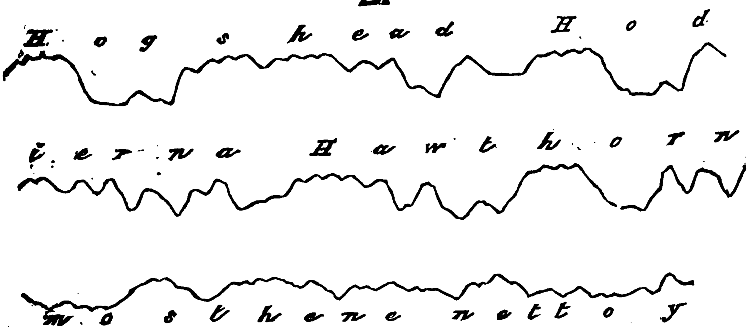
But when condensers are inserted between the cable and receiving apparatus, the very reverse of the above takes place. In

this case the first signal causes the indicator to travel a certain distance from zero, and each successive beat falls nearer and nearer to it. The figures 5, 0, 5, 0 on the slip "B" are examples of this.



A

B.

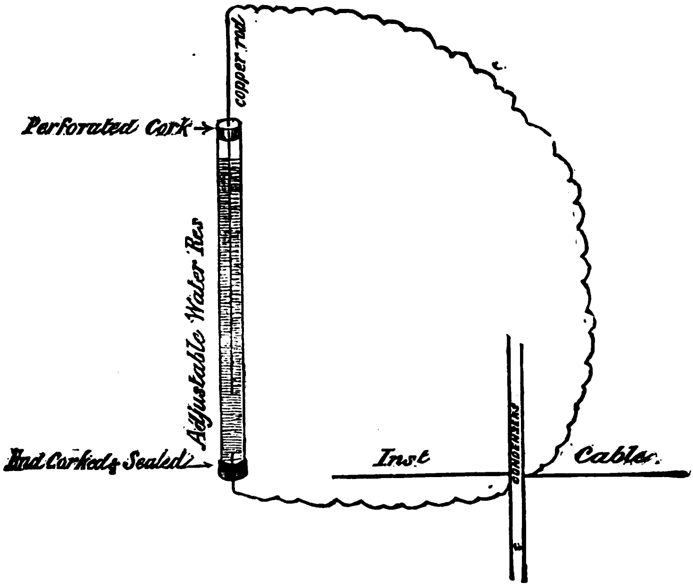


C.

If now an adjustable resistance be joined up to the two sides of the condenser, so that anything between 500,000 units and 0 may be inserted at pleasure, it will be observed, that by gradually reducing the resistance of this shunt, the above-mentioned tendency to fall towards zero after the first impulse becomes less and less marked, until a point is reached when all the beats are equal.

Reducing the resistance of the shunt beyond this point the signals gradually assume the form recorded at "A." Thus by the use of a shunt the action of the condenser can be so biased as to produce the most perfect, or convenient, form of signals.

In practice, I believe, most operators prefer the signals to have a slight tendency towards the form seen in "A," rather than fall in the direction noted in "B." Such signals will be found on "C."



As a matter of fact the signals recorded on the slips "A," "B," and "C" were received, on July 13th, 1877, under the three conditions mentioned, through a cable of 1,200 miles, having a conductor resistance of about 11 B.A. units, and capacity of ·4 microfarad per knot. The application of the shunt increased the speed of working fully 20 per cent.

A "water resistance" answers the purpose of a shunt very well, and affords a means of easy adjustment to the requirements of the circuit. A method of accomplishing this will be gathered from the accompanying diagram. A similar arrangement was in use some years, and gave great satisfaction, at this station.

MONTE VIDEO, *March 5th*, 1882.

ON THE WORKING OF THE BROWN-ALLAN CABLE RELAY.

By HENRY C. MANCE, Member.

These extremely sensitive relays have been worked in connection with the Persian Gulf cable during the last twelve months, with very satisfactory results. The principle of the instrument may be shortly described thus:—

In signalling by means of receiving instruments which make and break a local circuit, difficulties arise because the armature, or its equivalent, in the receiving instrument does not respond correctly to slight changes in the strength of the actuating current. In a Siemens relay, for example, if, after the tongue has reached the contact stop, the strength of the current increases, the tongue can only press harder against the stop, and will not move again until the strength of the current has become less than that at which the tongue was arrested. A similar thing happens when the strength of the current decreases to a minimum.

The Brown and Allan's relay, by a peculiar arrangement of the armature, is so adjusted that a change in the strength of the current causes an instant make or break in the local circuit. The novelty consists in having two armatures turning on one pivot, and pressed tightly against each other by means of a screw. The motion of the larger one follows the change of strength of the current, while the motion of the jockey is restricted by two contact pieces, as in the ordinary relay, and therefore cannot follow the movements of the former beyond the stops, but directly the motion of the armature is reversed, the jockey moves with it, and thus breaks contact with the stops.

It is not necessary here to enter at greater length into the description, but the following particulars, especially those regarding the translation arrangements recently adopted in connection with it, may prove interesting to telegraphists who are entrusted with the working of submarine cables over 400 miles in length.

The first relays sent to the Persian Gulf Department were, in consequence of their low sensibility, not sufficiently successful to

justify their superseding the ordinary Siemens relay; six (five-letter) words per minute was the highest speed obtainable through a cable of 1,000 knots, and this result was only obtained with considerable difficulty. One of these small relays with fixed coils was subsequently modified by me in Karachi, and the friction discs were replaced by a light fan of mica moving in linseed oil. The difficulty in adjustment at once disappeared, and the signals were much improved, but as the speed remained about the same, some larger cable pattern relays were obtained from the inventor for further trials.

The cable relays with suspended coils were an immense improvement on the first kind, and, after once being put in adjustment, gave unqualified satisfaction. It takes some time and a good deal of patience to adjust a Brown-Allan relay, so as to obtain the best results, but when once the desired adjustment is obtained it will frequently work for months without requiring any attention.

In the original directions for use, it is stated that for different lengths of cable it is best to use springs of various strengths to hold the coil in a central position between the poles of the permanent magnets. This would be inconvenient when the relay is used on a long cable with intermediate stations occasionally cutting in. On the Persian Gulf line the relay is first adjusted for the most distant station, and whenever the intermediate station comes in a leakage is applied, so as to take off a considerable portion of the current.

After once obtaining satisfactory results, the pole pieces are never moved, and the tension of the springs is left undisturbed.

The platinum contact-surfaces on the jockey should be perfectly smooth, and the points opposed to them fine. To prevent the spark arising from the extra current in the local circuit, shunts of the required resistance are applied, so as to divert it from the local contact-points.

It was found that occasionally, when delicately adjusted, the armature moved across the magnetic field sufficiently far to overpower the springs and allow of its being held firmly against the pole of the magnet on that side, absolute contact being, however, prevented by brass studs or pieces of cork. To prevent the

interruptions due to this cause, slight springs of German silver are placed in front of the poles. These do not interfere in any way with the working; but should the armature be deflected beyond a safe point, it is opposed by a slight pressure from the spring, and restored to its normal position without affecting the adjustment.

At the terminal stations a switch, which puts line to earth between "send" and "receive," is always used to prevent the discharge through the relay. At the intermediate stations, where the relay is generally used in connection with translation, this is not found necessary, as a permanent leakage is always attached to the line terminal of the relay, thus allowing only a small portion of the discharge to pass through its coils.

The double contact-points are a great convenience, as when one surface becomes dirty the other can be resorted to. The proof of good adjustment is being able to work on either point without any change in the signals. On the Persian Gulf line, the connections are, in every case, so arranged that one local contact point is always available in reserve; a switch is placed near each relay, and one turn of the handle, while reversing the line and earth terminals, at the same time changes the local circuit to the opposite contact point. In order to simplify the accompanying diagrams, this switch is not shown, but in practice they are always present.

In Plan No. 1, both local contacts are shown as in use at the same time, but, if preferred, an auxiliary relay of low resistance can be introduced; this is worked directly from one of the Brown-Allan contacts, and the printing armatures are actuated by the opening or closing of the auxiliary relay locals, instead of by the local battery on the Brown-Allan. This plan has the advantage of leaving one of the points in the latter free.

Siemens relays were at first always arranged in circuit, to be used in the event of anything going wrong with the adjustment of the Brown-Allan; but as this precaution is not now insisted on, they are omitted from the diagrams, as also in some cases, the keys, switches, and plugs necessary for station working.

When the office is on the ground floor, the Brown-Allan is usually supported on a pillar built up from the ground, but if in an upper story, it is placed on a stone slab built into the wall. All

the leads are kept apart from the land line connecting wires, and distinct earths, a considerable distance from each other, are employed for each instrument.

There are two circuits between Karachi and Bushire: the main circuit is cable for the whole distance, the other or minor circuit is half cable and half land line. The latter is worked by the single-current Morse system, and during the monsoon requires the occasional assistance of translation at one or two intermediate stations. The junction of cable and land line is at Jask, which station can, if necessary, cut in and give translation, also, on the main cable. This, however, is nearly always joined direct with a leakage of 2,000 ohms applied in the Jask office.

The speed obtained through 1,050 knots (the length of the main cable between Bushire and Karachi), when working direct, does not exceed 13 words per minute, but between the half-way station, Jask, and the terminal stations, Bushire and Karachi, double this speed is obtainable. With translation at Jask, Bushire and Karachi can correspond on the main circuit, at the rate of over 20 words a minute, which is a higher speed than is maintained in actual work. The signals are better than formerly, and there is a marked decrease in the number of errors and complaints regarding translation.

The minor circuit (cable and land line) works nearly as fast, and by this system of Brown-Allan translation, over 850 messages were on one occasion transmitted on this circuit in 24 hours during the interruptions which occurred on the eastern cables last monsoon.

To give satisfactory results in translation working, the relay should be stable and the local contact remain open after the tongue of the relay has conveyed the last signal. This is precisely the opposite to what takes place in the Brown-Allan. Its extreme sensitiveness renders it susceptible of being affected by the least vibration or change of earth current, and it frequently occurs that the local circuit, which, as a general rule, remains closed, will suddenly open without any apparent cause. The same result is generally observed when the relay is suddenly cut off from the line. It will easily be understood that these peculiarities rendered

it unsuitable for ordinary translation, and, as the requirements of the service demanded that translation should be resorted to, it became my duty to devise a fresh system specially for this instrument, and suitable also, if possible, to the signalling apparatus already in use.

The accompanying plans show the results arrived at, and the means by which satisfactory translation has been secured at Jask between two cables on the main circuit and between a cable and land line on the minor.

Plan No. 1 shows the translation arrangement for two cables with Brown-Allan relays. The central switch, similar to that shown in Plan 3, is omitted, as also the ordinary keys and commutators required for station working.

The dotted squares in the plan are supposed to inclose a complete Siemens-Morse ink-writer, such as is used for ordinary submarine translation, but with a few modifications to render it suitable for the new method. The whole of the inking arrangement and paper rollers, with their accompanying wheels, are removed from the apparatus, the adjustment of which is much simplified thereby. The clerk attending to translation is supposed to be able to read by sound.

To those who are not familiar with the mechanism of a Siemens submarine translation ink-writer, it may be necessary to explain that, at the first depression of the printing arm, the clockwork starts, and the back lever drops, thus putting line in connection with the printing armature. So long as the instrument is working, the back lever remains down, but on the cessation of signalling, the back lever, actuated by the clockwork, slowly rises and replaces line in connection with the relay. (In some of the instruments it has been necessary to reverse this action.)

The contacts, a, a', are additional, and intended to short-circuit or put in circuit, as the case may be, the local battery of the opposite instruments. When instruments Nos. 1 and 2 are working, *the locals of* 3 *and* 4 *are not affected by any accidental movement of No.* 2 *relay;* but directly relay No. 1 ceases to work, the locals of No. 2 are set free and left under the control of their proper relay.

It will be seen that it is quite immaterial whether the local circuit remains closed or open when the relay is at rest. There are two instruments on either side, and one of the back levers must be up and in contact with its relay. *So long as only one back lever is down, no current will pass out to line,* as the back lever of the one instrument is connected to the printing armature of the other. Directly, however, the relay commences to work, both back levers fall, and the positive currents from the right instrument pass to line through the back lever of the left, while the negative currents which represent the spaces between the signals pass to line through the right-hand back lever. As soon as the relay on the Karachi side ceases to work, one back lever immediately rises and reconnects the Bushire cable to its relay; at the same moment the locals of the Bushire relay are set free.

As the relays require no attention, all that the attendant has to do is to keep the instruments wound up. It will at first sight appear that two instruments out of the four will always be running, but this can easily be avoided in actual practice. For instance, during the transmission of a long despatch the clockworks can be stopped until the message is nearly finished, or, should the circuit be disengaged, the running instrument on either side may be stopped. It will be found that in the absence of any external disturbance the local circuit invariably closes as soon as sending ceases. Advantage should be be taken of this, and the right-hand instrument of each set kept permanently stopped with the back lever depressed; it then becomes necessary to keep only the left-hand instrument wound, so that it may run during the time it is in the act of translation.

Plan No. 3 has been adopted on the main circuit in temporary substitution of the foregoing method, as the additional instruments could not be easily spared, and translation on this circuit is at present not often required. It is found to answer remarkably well, although open to the objection that failure of the local circuit to close immediately after signalling ceases would temporarily interrupt translation. This, however, rarely occurs until the line has been idle a short time, and as the switch is then in its central position, with the commutator plug in S, either

station can call the other, the translation being started by the attendant pressing the switch either to one side or the other, or putting the plugs in T. The clockworks are so arranged in Plan 3 that the back lever *rises when the printing armature is permanently attracted*, thus stopping the clockwork and connecting relay to line. The central switch is useful in the event of anything going wrong with either apparatus. In such a case the plugs are left in S, and the clockworks stopped with the back levers depressed. The signals can then be translated by simply moving the switch to the side the signals are required to proceed. In Plan No. 3 it will be observed, that whenever the instrument on the Karachi side is working, the locals of the Bushire apparatus are permanently in circuit through the printing coils, and *vice versâ*.

Diagram No. 2 gives the very simple connections necessary for translation between a cable and land line. In the right-hand instrument the *back lever falls whenever the printing armature is attracted*; in the left-hand instrument it commences to *rise* directly the printing arm is *depressed*.

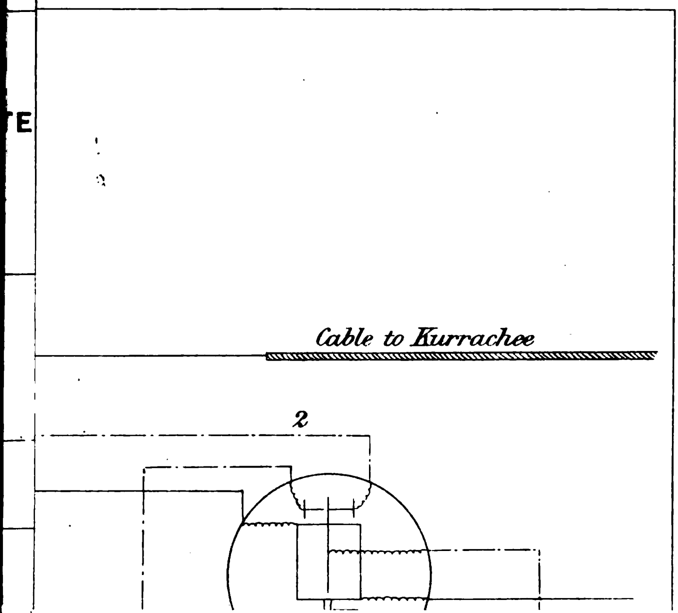
During such time as the Siemens land line relay is working the contact-points, *a*, *a′* are closed, preventing the possibility of the line being cut off by any movement in the Brown-Allan relay; but as the Siemens relay always remains open when at rest, no precautions are necessary in respect to the local battery on that side.

In this system it is quite immaterial whether the Brown-Allan relay local circuit remains open or closed. If the printing armature is down, the back lever rises and connects line to relay. If the contrary is the case, the back lever falls, and the relay is connected up through *c* and *d*. In every case, whenever an instrument is working the back lever remains down, and whenever a lever rises the clockwork stops.

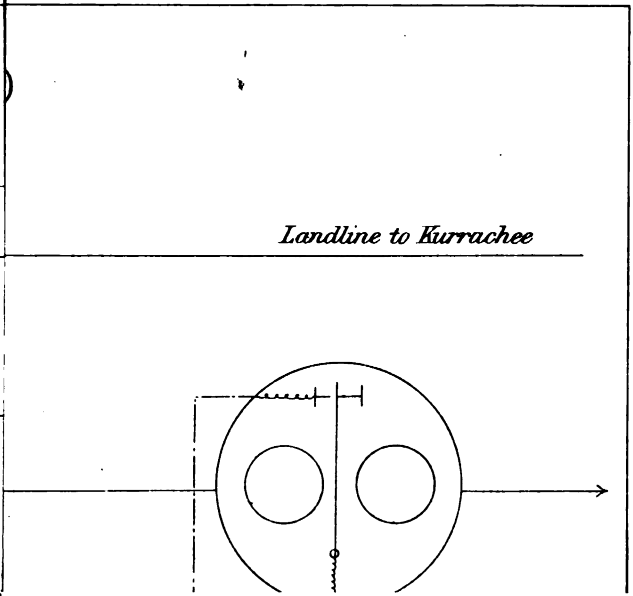
Special instruments more suitable for use in connection with unstable relays are now being constructed for the Persian Gulf Telegraph Department, and it is believed that the necessity for translation supervision will be greatly reduced as soon as the new instuments are obtained.

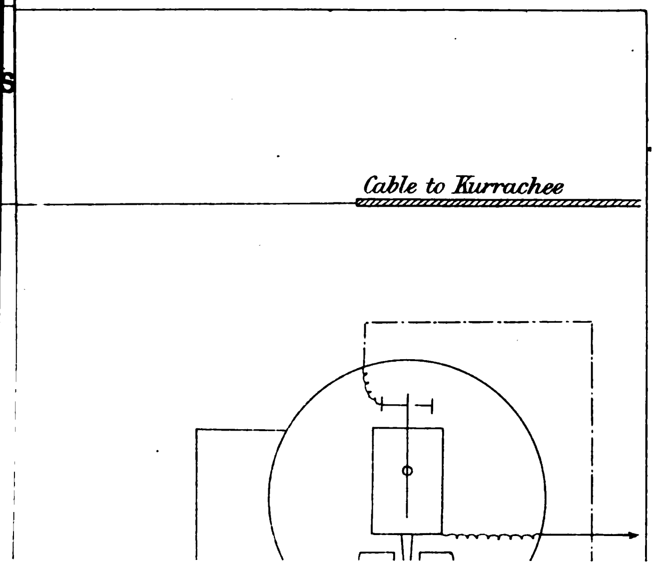
HENRY C. MANCE,
Engineer and Electrician, Persian Gulf Telegraphs.

KARACHI, 1st *February*, 1882.


Cable to Kurrachee
2

F





g paper was then delivered by Professor W.
on, F.R.S. :—

JOURNAL

OF THE

SOCIETY OF

Telegraph Engineers and of Electricians.

VOL. XI. 1882. No. 43.

The One Hundred and Thirteenth Ordinary General Meeting of the Society was held at the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday evening, May 11th, 1882—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the previous meeting were read and confirmed, and the names of new candidates were announced and suspended.

The PRESIDENT: The Council of this Society is generally so punctual, that a few words may well be said to account for their being ten minutes after the usual hour to-night. The reason was a very good one, and I may as well inform the meeting that the Council was engaged on a very important discussion with reference to the subject of the "Wire Gauge."

The SECRETARY announced that since the last general meeting donations to the Library had been received from Major S. Flood Page, of the Crystal Palace; from Mr. J. Sivewright, C.M.G., Local Hon. Sec. to the Society at the Cape; and also from the Royal Engineer Institute.

A vote of thanks was accorded to the donors.

The following paper was then delivered by Professor W. E. Ayrton, F.R.S.:—

MEASURING-INSTRUMENTS USED IN ELECTRIC LIGHTING AND TRANSMISSION OF POWER.

By Professors W. E AYRTON, F.R.S., and JOHN PERRY, M.E.

During the last two years an enormous impetus has been given to the development of the electric light and electric transmission of power; and, as accurate measurements form the basis of commercial success in this as in any other branch of engineering, we hope you may not find it too tedious listening to a short description of the details of certain instruments that we have devised and have had constructed for making accurately, and at the same time quickly, the measurements that are necessary to be made, in order that an estimate may be formed of the commercial success of any special system of electric lighting or transmission of power.

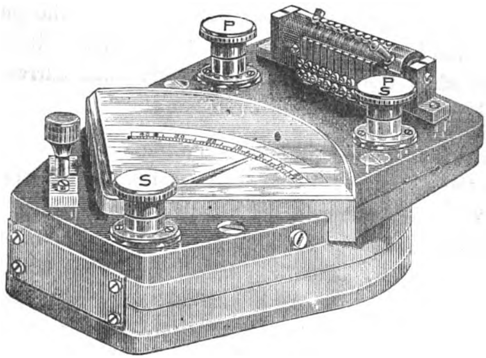
After the most charming paper given us at our last meeting, by Mr. Stroh, and of which the recollection must for a long time remain in all our minds, we feel that some apology is due to you for the rather prosy production which to-night follows it.

The chief objection to instruments used in measuring strong currents is that, first, the deflections are not proportional to the current, and, secondly, there is no easy method of calibrating the instrument—that is, of ascertaining the strength of the current that is necessary to produce any given deflection. At the end of 1880, we tried in our "illuminator," used in connection with our apparatus for seeing by electricity, a method that has since been described by MM. Deprez and Carpentier, for making the deflection approximately proportional to the current. This consisted in placing the axis of the coil, not, as is usual in galvanometers, at right angles to the axis of the permanent magnetic field, but at an acute angle with it, so that, instead of, as is usually the case in ordinary galvanometers, the magnetic moment due to the current diminishing as the needle is deflected, while that due to the permanent controlling field increases, and in consequence of which the current must increase much more rapidly than the deflection, our plan of sloping the coil causes the magnetic moment due to the currents to increase

up to a certain point. But in our later instruments, indeed in all instruments with permanent magnetic fields that we have made since the commencement of 1881, we have abandoned this method in favour of giving to the coil, needle, and pole-pieces exactly the shape that theory shows to be necessary to obtain deflections exactly proportional to the current.

1. *Commutator Ammeter.*

Last year we had the honour of bringing before the Society an instrument by means of which strong electric light currents can be measured, and yet which can be calibrated by the employment of a single Daniell's cell. This instrument, which we have since called an "ammeter," short for ampère-meter, contains, as the



COMMUTATOR AMMETER AND VOLTMETER.

members will remember, a coil consisting of ten strands, each of exactly the same resistance. These ten strands, by means of a simple commutator, can be joined either in series or in parallel circuit, and so the sensibility of the instrument can be increased exactly ten times without altering the dead-beat character of the instrument, which latter is produced by the extreme lightness of the needle and corrugated aluminium pointer and by the great strength of the magnetic field.

To calibrate the ammeter, the commutator is turned to series, and a current sent through the instrument by a cell of known electro-motive force, E, but of unknown resistance, producing, say,

a deflection, D_1; the plug attached to the instrument is now taken out, which has the effect of adding a resistance of one ohm to the circuit, and a second deflection, D_2, obtained. From this it can easily be shown that a current of $10 \frac{D_1 - D_2}{D_1 D_2}$ E ampères will produce 10° deflection when the commutator is in series, or 1° deflection when the commutator is to parallel.

Many of the instruments are adjusted to give 1 ampère per degree when the commutator is to parallel; others, again, are arranged to give 2 ampères per degree; while some go as high as 5 ampères per degree, and therefore measure currents of over 200 ampères.

In designing this commutator ammeter, we originally only thought of using the high grade of sensibility for the purpose of calibrating the instrument, but we have since found it extremely convenient when testing the comparatively small currents of 0·5 to 2 ampères used with incandescent lamps.

2. *Commutator Voltmeter.*

Since the reading of that paper, we have constructed a commutator voltmeter on much the same principle, but in this case each coil has a resistance of 40 ohms, so that when in series the instrument has 400 ohms resistance, and when parallel only 4 ohms, whereas in the ammeter the resistance in series is about 0·3 ohms and parallel 0·005, the latter being more than one-hundredth of the former, in consequence of the resistance of the small leading wires inside the instruments.* The ammeter is calibrated in series and generally used in parallel circuit, whereas the voltmeter is calibrated in parallel circuit and used generally in series, and then indicates from 1 volt per degree in some instruments to 5 volts per degree in others, the total deflection of 45° in the latter case corresponding with 225 volts. But just as the ammeter can be conveniently used in series, when testing the comparatively small currents passing through a single incandescent lamp, so the

* The voltmeters are now made with each coil having a resistance of 200 ohms, so that the instrument in series has a resistance of 2,000 ohms, and in parallel circuit, 20 ohms, the resistance coil being also of 20 ohms.

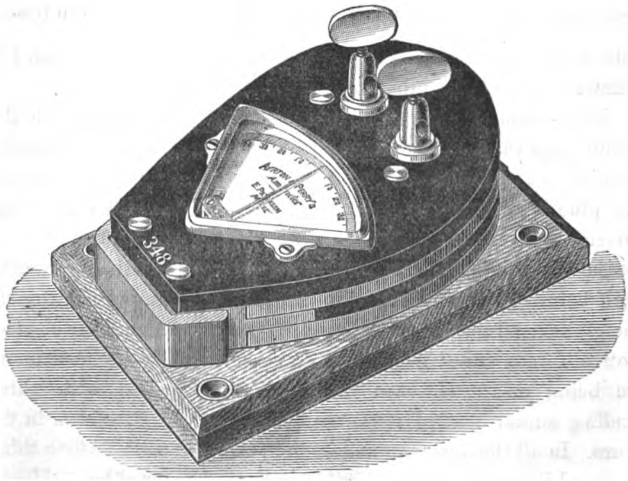
voltmeter may be used in parallel circuit for testing electro-motive forces of two or three volts, such as, for example, the electro-motive forces of one or two Faure's accumulators. To calibrate the voltmeter, the commutator is turned to *parallel*, and a current sent through the instrument by a cell of known electro-motive force, E, but of unknown resistance, producing, say, a deflection of D_1; the plug attached to the instrument is now taken out, which has the effect of adding a resistance of 4 ohms, and a second deflection, D_2, obtained. From this it can easily be proved that an electro-motive force $10 \frac{D_1 - D_2}{D_1 D_2}$ E volts between the terminals of the instrument will produce a deflection of 10° when the commutator is to parallel, or 1° when to series.

In the ammeter the resistance coil can be introduced in the circuit *only* when the commutator is to series, and in the voltmeter *only* when to parallel, so that in neither case can it be fused by the plug being accidentally taken or left out when a strong current, or, in the second case, a large electro-motive force, is being measured. And more than this, to avoid the coils of the instrument itself being fused, or the needle being damaged by the intrument being arranged for maximum sensibility when currents or electromotive forces suitable for the $\frac{1}{10}$ sensibility of the instrument are being measured, each instrument is provided with three binding screws marked respectively S, (PS), and P, as seen in the figure. In all the newer ammeters the screw P is suitable for a thick wire, and S only for a thin, (PS) being suitable for either. Hence the wires from a dynamo, for example, can only be attached to (PS) and P, and not possibly to S. Now a current can only pass through the instrument from (PS) to P when the commutator is to parallel. Hence, if accidentally left to series, the circuit is merely interrupted, instead of the coils being fused or the pointer damaged by too large a deflection. Precautions of a similar kind are also taken in the construction of the voltmeter, by the use of three distinct binding screws on the instrument.

All the instruments are so wound that, when a current is sent from binding screw to binding screw, at each side of the commutator, the pointer points to that binding screw at which the positive current enters.

3. *Non-commutator Ammeter and Voltmeter.*

In electric light factories or other places where many ammeters or voltmeters are employed, it is of course unnecessary that all should be provided with commutators for easy independent calibration. It is sufficient that a few of the ammeters and voltmeters should have commutators for independent calibration, the remainder, which in that case are made as shown in the following figure, being calibrated by direct comparison with the commutator ones.



NON-COMMUTATOR AMMETER AND VOLTMETER.

In all our instruments the needle and pointer are pivoted by an axis passing through their common centre of gravity, so that the deflection is unaltered, no matter in what position the instrument be held, and, the pivot resting in jewels top and bottom, the friction is also practically unaltered by turning the instrument on its side or holding it upright. The permanent attached magnet is also so strong, that the ammeters or voltmeters may be placed not very far from even a dynamo machine in action, without the magnetism of the machine affecting the indication of the instruments.

One difficulty, however, has practically arisen in the use of these instruments, and that is, although the special mode of winding adopted, combined with the existence of the commutator, enables any one by means of a single good Daniell's cell to calibrate his instrument for himself, practically Daniell cells do not exist at many places where there are electric light installations, and consequently people do not calibrate their instruments for themselves, and so do not detect the charges of magnetism in the permanent magnets which necessarily occur, and against which the user is warned by a notice stuck in the lid of the box accompanying every ammeter or voltmeter.

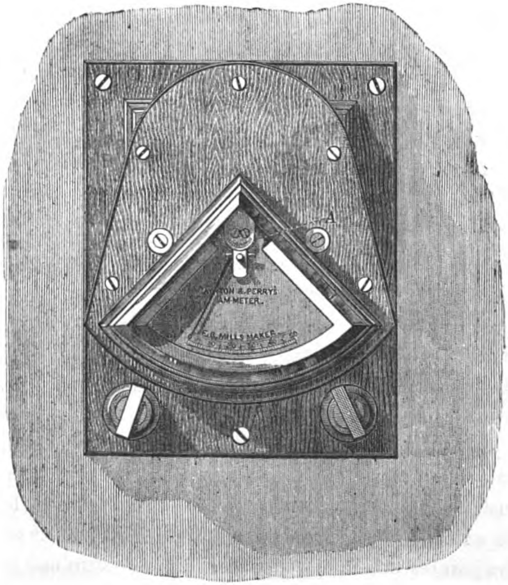
To partially avoid the loss of mangetism in the controlling permanent magnets, an armature, seen in the last figure, is supplied with each instrument, but which of course must be removed when the instrument is in use.

4. *Spring Ammeter and Voltmeter.*

To however completely overcome this difficulty of loss of magnetism in the permanent magnets, we have decided to abandon permanent controlling magnets, and so we have constructed ammeters and voltmeters like those shown in the following figure, and in which the controlling force is that of either a flat or a cylindrical spiral spring, A, the axis of the soft iron needle in this case making an angle less than a right angle with the axis of the coil when no current is passing, since if it made a right angle it would be in unstable equilibrium when a current passed. The best angle that the axis of the needle should make with the axis of the coil when the pointer points to nought, we have determined partly by calculation and partly by a long course of experiments, and we find that, with a proper initial adjustment, we can obtain deflections of the pointer up to 45° *directly* proportional to the current.

These instruments possess two important advantages not possessed by any of our earlier forms—the one being that they can be used with reverse currents; the second, that by giving any special set to the spring (for doing which there is a small hand seen in the figure, and which can be turned through any angle indicated by a small graduated scale, A, under it,) the needle

does not start from the zero position until the current in the ammeter or electro-motive force in the voltmeter exceeds a certain prearranged limit. This method of giving a set to the spring greatly increases the sensibility of the instrument. Suppose, for example, currents of about 30 ampères, or currents varying, say, from 25 to 35 ampères, are to be measured with a special instrument, then instead of the pointer starting from nought for even a small current, a set is given to the spring, so



Spring Ammeter and Voltmeter.

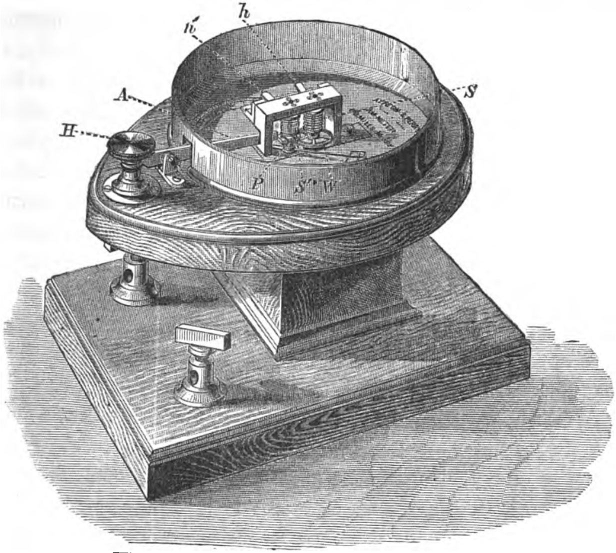
that the pointer does not leave the zero until a current of 25 ampères traverses the coils. In the former case, the spring would have to be so strong that the total possible deflection, 45°, was produced by the 35 ampères—that is, about 1·3° per ampère; whereas, in the latter case, a weaker spring set-up would be used, such as to be deflected through the 45° for an addition of 10 ampères to the 25 necessary to start the pointer. In the latter

case, we should have 4° per ampère, or a sensibility about three times as great as before.

Spring voltmeters on a similar principle we have also had made.

5. *Wheel and Pinion Ammeter and Voltmeter.*

Where still greater delicacy is required, the form of the instrument is somewhat changed. Attached to the arbor of the needle is a wheel, W, with extremely finely cut teeth gearing into those of a pinion, P, on the arbor to which the pointer is



WHEEL AND PINION AMMETER AND VOLTMETER.

attached. With this arrangement the motion of the pointer is magnified ten times. If, then, the coil and needle have such a shape, and the axis of the needle makes such a proper initial angle with the axis of the coil that the deflection of the needle up to not more than even 36° is proportional to the current, then with our wheel and pinion arrangement the deflection of the pointer over the entire scale of 360° will be proportional to the current. In addition to these, both the arbor of the needle as well as the

arbor of the pinion are provided with very delicate cylindrical spiral springs, S, S′, one or both of which may be employed, since the latter can be thrown out of gear by raising the arm, A, which is done by turning the head, H, of the adjusting screw. If both the springs be of the same strength, then the sensibility of the instrument can be instantly made exactly one hundred times as great by turning the milled head, H, which raises the arm, A, and throws S′ out of gear, or can be increased to any other known less or greater prearranged amount, by having the spring on the pinion weaker or stronger than that on the wheel.

Both springs have, further, little hands, h, h' (seen in the figure), for setting them up, so that the whole deflection of 360° may, if desired, be produced by a small percentage of change in the total current when it is wished to measure accurately small changes in a fairly constant current. The wheel and pinion ammeter, then, furnishes an instrument for the measurement of strong currents, comparable in delicacy with the instruments usually employed for the measurement of only weak currents. Every bearing is jewelled as it is in a good watch, hence the freedom of motion is very great.

An ammeter on this principle we are now constructing, to measure up to 1,200 ampères.

On a similar principle, we have constructed wheel and pinion voltmeters, with two grades of sensibility, for measuring electromotive forces with great accuracy.

By means of simultaneous measurements of the currents flowing through a circuit, and the difference of potentials between its two ends, the horse-power electrically given to that circuit can be ascertained, since this horse-power equals A × V × ·00134, where A is the current in ampères and V the difference of potentials in volts; also A × V × 44·25 equals the number of foot pounds of work per minute electrically given to that part of the circuit.

6. *Bifilar Suspension Electric-power Meter.*

In the paper read by us last spring at the Society of Arts, we described an electric-power meter which we had arranged

for measuring by one observation the horse-power electrically given to any part of the circuit, and which, by the employment of our commutator principle, could be calibrated by employing very much smaller powers than the instrument was intended to usually measure. At the York meeting of the British Association, we exhibited the instrument which we had been employing for this purpose, consisting of a coil of very fine wire wound on a long thin bobbin, so that the coil had a very small moment of inertia, capable of moving about an axis parallel to the length of the bobbin. The coil was bifilarly suspended inside another fixed coil containing ten thick wires, each of exactly the same resistance, and which, by means of the commutator, could all be joined up in series or in parallel.

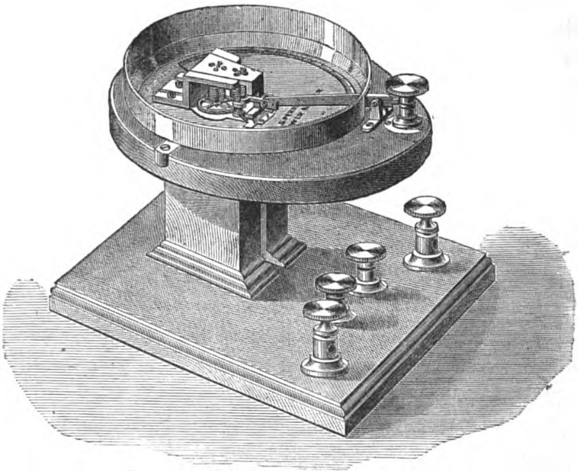
The thick wire coil is placed in the main circuit, while the fine wire coil acts as shunt to that part of the circuit, P Q, the horse-power electrically given to which it is desired to measure. The current passing through this fine wire coil therefore measures V, the difference of potentials between P and Q, hence the deflection of the coil measures the product of the main current A and V, and consequently the horse-power being electrically given to P Q. By turning the commutator to series, the sensibility of the instrument can be increased exactly ten times, either for the purpose of calibration, or when it is required to measure the power being given to, say, one incandescent light.

At the same meeting of the British Association, Sir William Thomson, before seeing our electric-power meter, described an instrument he proposed constructing on the same principle, and which he called an electro-ergometer. We have not employed this name, because it appears to us to be not quite apt, since such an instrument measures the rate of doing work which is power, and not the *ergs* or amount of work done.

7. *Wheel and Pinion Electric-power Meter.*

This year we have modified our electric-power meter, employing the wheel and pinion and double spring already described in connection with the wheel and pinion ammeter and voltmeter, so that this instrument now takes the shape shown in the following figure.

The outer and larger binding screws are for taking the wires which form part of the main circuit; the inner smaller binding screws for the finer shunt wires which are attached to that part of the circuit, the energy electrically expended in which it is desired to



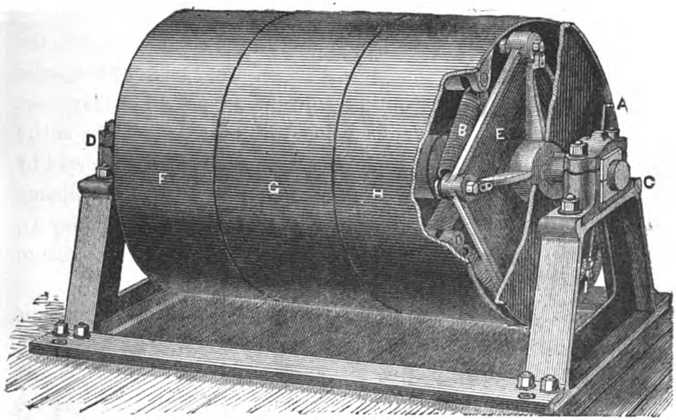
WHEEL AND PINION ELECTRIC POWER METER.

measure. One or both springs can be employed, and so two very different grades of sensibility are possible; also a definite amount of angular set can be given to either, so that a small change in a large horse-power will cause a great change in the deflection of the pointer.

8. *Transmission Dynamometer and Dynamometer Coupling.*

When describing our original ammeter to this Society, we described a form of transmission dynamometer we had devised for measuring the power given by an engine to a dynamo or to any other driven machine, and to this instrument we have recently added the same contrivance of a set-up spring used in the wheel and pinion ammeter and electric-power meter, to limit the whole range of the instrument to not very large changes on each side of the normal horse-power to be measured, and by this means to obtain with a limited scale great delicacy near the normal

measured power. The instrument, as seen in the figure,* consists of a pulley, F, rigidly fixed to the shaft, C D, a loose pulley, G, and a pulley, H, joined by the spiral springs, B, to the ribbed plate, E, which is rigidly fixed to the shaft C D. If, then, the engine belt is on F, and the belt to the dynamo or driven machine on H, or *vice versa*, the springs, B, will be stretched, depending on the "torque" or twist transmitted. The extension of these springs causes, by means of a small link-motion seen at the lower right hand curve of the figure, the bright bead, A, at the end of a long arm to approach the centre. Hence the smaller the radius of the



TRANSMISSION DYNAMOMETER.

circle described by this bright bead as it revolves, the greater the torque. Consequently, the horse-power transmitted is at once obtained from observing the indicated torque and the speed of rotation. The arm carrying the bead is slightly flexible, and when no power is being transmitted the bead is pressed with a certain force against the rim of the front plate, hence the bead does not commence moving until a certain prearranged horse-power at a given speed is being transmitted; its whole radial motion, therefore, is

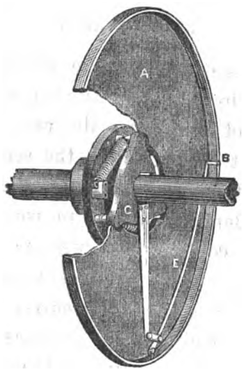
* This and the following figure are from blocks used in Professor Perry's book on "Practical Mechanics," about to be issued by Messrs. Cassell, Petter, & Galpin, who have kindly granted us the use in advance of these two illustrations.

completed for a certain additional transmitted horse-power, the necessary addition depending on the power of the springs and the leverage of the link-motion. Consequently, a large change in the radius of the circle of light is produced by a small change in the transmitted horse-power. Further, one of the pins in the links can be taken out and put into another hole, which has the effect of greatly altering the leverage of the links, thus increasing the magnification and causing the motion of the bead to be completed for another range of power. For example, the springs and link-motion may be so arranged that with one of the two adjustments the bead may commence to move when 8 horse-power is being transmitted at a certain speed; the whole motion from the circumference to the centre may be completed, when the horse-power transmitted varies from 8 to 12. With the other adjustment, the bead may start moving when 4 horse-power is being transmitted, and the entire travel of the bead from the circumference to centre completed by this transmitted horse-power increasing from 4 to 6. Slipping either the driving or the driven belt on to the loose pulley G, causes the transmission dynamometer and the dynamo machine to stop while the engine is going on.

The next figure shows our dynamometer coupling, which differs only from the preceding in that it is intended to be used with machinery driven directly by shafting where belting is not employed. For instance, this coupling may be used to measure the horse-power given by a fast-speed engine to a dynamo driven directly by it, or it may be employed to measure the power given by a marine engine to the screw or to the paddles, or generally the horse-power transmitted along any line of shafting; the spring coupling, in fact, replacing the ordinary coupling used with such shafts.

One of the halves of the coupling seen in the figure is keyed to the driving shaft,—for example, the shaft of a fast-speed engine,—and the other to the driven shaft,—for example, that of the dynamo. The half C is attached to the other half by means of the spiral springs, and the stretching of these is therefore a measure of the torque. The angular motion of the one relatively to the other causes the bright bead, B, to approach the centre, and, as before, the

radius of the circle of light measures the horse-power transmitted at any particular speed. The arm E, carrying the bead, is also, as before, slightly flexible, so that when no power is being transmitted the bead, B, is pressed with a certain force against the rim of the larger plate. Hence the bead does not commence to move until a certain prearranged horse-power, at a given speed, is being transmitted, and the whole motion is completed for any prearranged excess beyond this, thus enabling delicate measurements to be made at powers a little more or less than that normally transmitted.



DYNAMOMETER COUPLING.

By a proper arrangement of the link-motions, we have succeeded in making the radial motion of the bead in both instruments exactly proportional to the extension of the springs or twist transmitted.

The transmission dynamometer and dynamometer coupling just described have the great advantage over any sort of laboratory dynamometers, in that the former have not to be put into position and adjusted for each particular experiment, but are always ready, and are always indicating the power transmitted at any given speed. If, for example, a dynamometer coupling be inserted in the shafting of a factory in place of the ordinary coupling, a glance at it at any time will show the power that is being transmitted by it. If two such dynamometer couplings be inserted

at two places in the same set of shafting, the difference between the transmitted powers indicated by them is the power utilised by the machinery driven by that portion of the shafting that is between them. At present, masters of works, we think, have necessarily but rather a vague idea of the amount of power expended in different parts of their works—how much, for example, is used to drive one portion of the machinery and how much to drive some other. The substitution of a few dynamometer couplings, at well-chosen places, for the ordinary couplings, would settle this question.

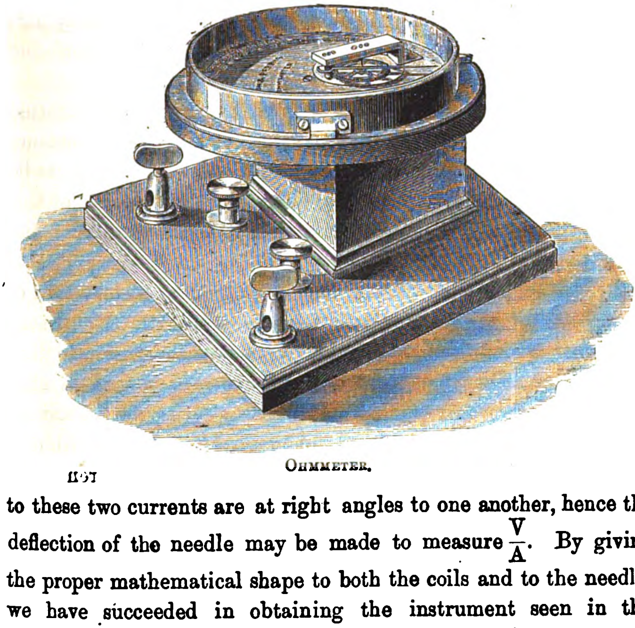
9. *Ohmmeter.*

The next instrument, which, like all the preceding electric ones, is constructed by Messrs. Paterson, of 76, Little Britain, is for the purpose of measuring the resistance of any part of, say, an electric light circuit, while the strong current is flowing. At present the resistances of the field magnets, the bobbins of electric lamps, etc., are measured with the Wheatstone's bridge when cold, and a guess is made at their resistance when hot by making a rough estimate of the temperature. A better plan than this is to stop the current, and quickly measure the resistance before the circuit has had time to cool; but even this method of measurement can only lead to approximate results, and is of course quite inapplicable to the resistance of either an arc or an incandescent light. In such cases it is usual to measure the main current in ampères with an ammeter, and the diffe. ce of potential in volts with a voltmeter, between the two terminals of the lamp, since dividing the second reading, V, by the first, A, we have the ratio $\frac{V}{A}$ or R, the required resistance. And this method we have been in the habit of employing, not merely to measure the resistance of a lamp, but the resistance possessed by any part of the circuit while the current was flowing through it.

To avoid, however, always having to take two measurements, we devised some months ago an instrument which we have at length perfected, for measuring the ratio at one reading, and this instrument, called an "ohmmeter," differs from the power meter in

that, while the latter measures the product, V A, the ohmmeter measures the ratio, $\frac{V}{A}$.

This instrument consists of two coils, one of thick and the other of fine wire. Both coils are fixed, and with their axes at right angles to one another, and the currents flowing through each acts on the same needle. Through the thick coil the whole current, A, flows, and through the fine coil a shunt current which measures V, the difference of potentials between the two ends of the part of the circuit the resistance of which it is required to measure; and the forces due



OHMMETER.

to these two currents are at right angles to one another, hence the deflection of the needle may be made to measure $\frac{V}{A}$. By giving the proper mathematical shape to both the coils and to the needle, we have succeeded in obtaining the instrument seen in the accompanying figure, in which the deflections from zero are directly proportional to the values of $\frac{V}{A}$, that is, to the values of the resistances to be measured.

When the instrument is not in use, there is no directing force acting on the needle, and the pointer therefore remains anywhere. On allowing the main current to pass through the thick coil,

by means of the outer and larger binding screws, the axis of the needle instantly places itself along the axis of the thick coil, and the pointer points to nought. If now wires be attached to each of the small binding screws belonging to the fine coil, and the other ends of these two wires be attached to the *same* point of the main circuit, the pointer still remains at nought, indicating that there is no resistance in the main circuit between the two points of attachment of the fine wires. If these wires be separated by, say, the field magnets of the dynamo, the pointer at once moves to a number indicating the resistance of the field magnets, etc. It will be seen, then, that the resistance of any part of the circuit can be measured at any time without interfering with the main current.

In actual practice, in fact, the ohmmeter is simply kept inserted in the main circuit anywhere, and when it is desired to measure the resistance of any part of the circuit, all that is necessary to be done is to connect, by means of two fine wires, the two ends of this part of the circuit to the two smaller binding screws of the ohmmeter.

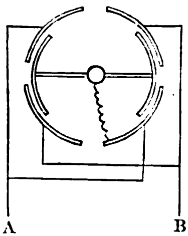
By the employment of the wheel and pinion, a deflection of about 320° of the pointer is obtainable, and with the present instrument a deflection of 60° corresponds with 1 ohm, so that measurement of resistances up to 6 ohms correct to $\frac{1}{60}$ of an ohm can be accurately and quickly made. By altering the resistances of the two bobbins, the measured resistance corresponding with any particular deflection can be made anything we please.

One great use of the ohmmeter is that it enables us to dispense with resistance coils for experiments on dynamo machines. Any one who has used the resistance coils made for such purposes knows the difficulty of making coils of convenient size, whose resistances do not seriously alter with currents of 30 or 40 ampères. The coils cannot easily be made to cool fast enough to avoid the resistance seriously increasing with the current. We, on the other hand, use a bit of carbon, a bit of wet rope, or a pail of water, and measure with the ohmmeter the resistance of our extemporised resistance coil at the moment of making any experiment.

10. *Cylinder-spring Electrometer.*

For measuring differences of potential higher than 500 volts, the voltmeters already described are unsuitable, and recourse must be had to a portable modification of some form of Thomson's electrometer. We have devised two or three forms, one of which is seen on the table.

Two vertical pieces of metal, forming part of a cylindrical surface, are attached to a vertical arbor resting in jewelled bearings, and form the needle of the electrometer. This arbor is fixed to one end of an extremely fine spiral spring, the other end of which is fastened to the dial plate, which is itself electrically connected with one of the terminals, A. This spring serves two purposes—the one to give the needle directive force, the other for keeping up electric connection with the needle which turns inside four concentric vertical pieces of brass, which together nearly form



a complete cylinder of a radius slightly larger than that of the needle, and which replaces the quadrant in the ordinary electrometer. These are electrically connected alternately in pairs, as shown in the small figure; and one pair is also connected with the needle through the very fine cylindrical spring, symbolically represented as a spiral line in the small figure. If, now, A and B be maintained at a difference of potential, E, a deflection, D, will be produced, which it may easily be shown is proportional to the square of E. One great advantage of this well-known method of connecting up the needle and quadrants of a Thomson's electrometer is, that although it does not produce as delicate an instrument as can be obtained by giving to the needle an independent charge, it enables the instrument to be used for measuring a rapidly-

reversing electro-motive force equally well as for measuring a non-reversing electro-motive force; whereas a fine wire galvanometer or dynamometer cannot be satisfactorily used for measuring even a small rapidly-reversing electro-motive force, on account of the retardation arising from self-induction.

The advantage of the special modification above described of the quadrant electrometer is that it is portable; and from the needle having but a small moment of inertia, while at the same time it is everywhere very near the fixed attracting surfaces, the instrument may be made partly dead-beat, and at the same time sufficiently delicate to measure the large electro-motive forces for which it has been designed.

If it is desired to measure the horse-power electrically expended in any portion, P Q, of a circuit conveying an alternate current, a measurement of the strength of the current may be made with a suitable ammeter, and a simultaneous measurement of the difference of potentials between P and Q with an electrometer. The following arrangement of the electrometer, however, enables the mean product of the alternate current and alternate difference of potentials between P and Q to be measured with the one instrument:—

Let it be desired to measure the energy electrically expended in a portion of the main circuit between two points, A and B, whose potentials are P and Q respectively. Connect these two points to the opposite fixed cylinders in the previous electrometer. Place in the main circuit, on either side of the portion A B (say, on the A side), a resistance, R, having no self-induction, and let its farther end, C, of which the potential is S, be connnected with the movable cylinder of the electrometer; then the deflection, D, measures the mean value of $(P - Q)\left(S - \frac{P + Q}{2}\right)$. Now connect the needle with A, instead of with C; then the deflection, D, measures the mean value of $(P - Q)^2$. Hence $D - D'$ measures the mean value of $(P - Q)$ $(S - P)$, which is obviously R times the mean value of the energy expended on the portion of the circuit A B.

A variation may be made in the second test, and which consists in connecting the needle with a point, D, in the resistance coil, such that the resistance between D and A is $\frac{R}{2}$; in that case D″ will measure the mean value of $(P-Q)\left(\frac{S+P}{2}-\frac{P+Q}{2}\right)$, in which case D−D″ measures the mean value of $\left(\frac{P-Q)\ (S-P}{2}\right)$, or $\frac{R}{2}$ times the mean value of the energy expended.

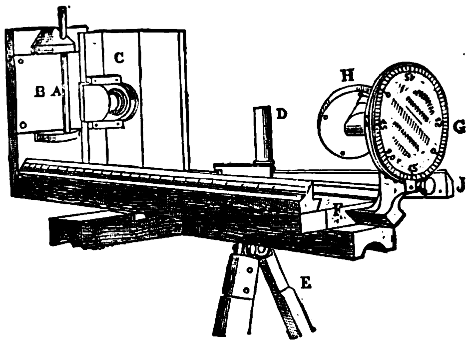
12. *Dispersion Photometer.*

With this photometer measurements may be made in quite a small room of the illuminating power of the rays coming at any angle from even a powerful electric light. With the ordinary forms of photometer, the screen illuminated by the electric lamp must be placed so far away from the lamp that its brightness is the same as that of another screen, or of the other side of the same screen, illuminated by the standard candle. With the powerful electric lamps of the present day, a distance of 50 or 100 feet is necessary, in order that a measurement may be made of the illuminating power by means of an ordinary photometer, and, in addition, it is very difficult to examine the light unless it comes from the lamp in a horizontal direction.

The principle of our dispersion photometer consists in the use of a concave lens to weaken the strength of the light (instead of placing the lamp far away from the screen), combined with the employment of a mirror turning round a horizontal axis, which makes an angle of 45° with its reflecting surface, in consequence of which rays coming at any angle from the lamp can be measured without the introduction of an error arising from the varying absorption at different angles of reflection; while at the same time a pointer attached to the mirror reads off on a graduated scale, G, attached to the instrument, the angle made with the horizontal by the beam of light under examination.

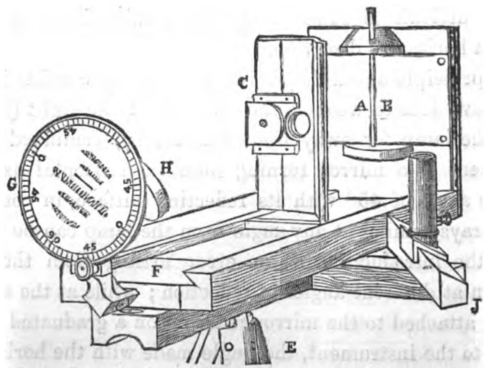
The instrument seen in the figures consists of a portable tripod-stand, E, on which is screwed a small table, which is then carefully levelled. The photometer is next placed on this table, and the pin at F, directly under the centre of the mirror, is passed through

the base of the photometer into the hole in the table. The photometer, by turning round this pin, can, without producing any change in the distance of the centre of the mirror from the lamp, and therefore without changing the distance from the screen to the



Dispersion Photometer.

lamp, receive the small horizontal motion necessary for the adjustment for a new inclination of the rays coming from the electric light. The divided circle, G, is clamped with the index at 0°,



Dispersion Photometer.

the electric lamp is lowered or raised till the illuminated disc formed on the screen of blotting paper, G, by the reflected light, passing afterwards through the lens, is in the middle of the paper screen. A little sliding shutter with a fine hole

in its centre, seen in the last figure, enables a very exact adjustment to be made; but in practice we find that we get sufficient accuracy without the use of the shutter. The instrument having been thus adjusted, the distance from the electric lamp to the centre of the mirror is next measured.

The candle in the holder, D, sliding on the graduated rod, J, having now been lighted, there will be seen cast on the screen of blotting paper, B, two shadows, side by side, of the black rod, A, placed in front of it, one being cast by the standard candle, the other by the beam from the electric light after reflection at the plane silvered mirror, H, and dispersed in passing through the concave lens in the sliding wooden frame, C. The lens is now moved backwards and forwards until the intensities of these two shadows are equal when seen through the sheet of red glass supplied with the instrument, and again adjusted until the shadows are of the same intensity when seen through the sheet of green glass. d, the axial distance of the lens from the screen, as shown by the pointer attached to the lens frame on the fixed graduated scale, as well as c, the distance of the candle, also shown by the position of its pointer on its graduated scale, are now noted; whence if f is the focal length of the lens, and if D is the distance of the lamp from the paper screen (that is, the distance of the lamp from the mirror plus the fixed distance of the mirror from the screen), and if L is the strength of the examined source of light in standard candles,

$$\sqrt{L} = \frac{D-d}{c}\left\{1 + d\left(\frac{1}{f} + \frac{1}{D-d}\right)\right\},$$

or

$$L = \frac{1}{c^2}\left\{D + \frac{d(D-d)}{f}\right\}^2.$$

We prefer to employ the formula; but as all the common instruments which have hitherto been manufactured have lenses whose focal length is 4 inches, we have prepared a table, a copy of which is sent out along with each instrument, in which the value of L is given for various values of D, d, and c. Using this table, it is necessary to have the lamp at either 60, 120, or 300 inches from the screen; the candle is either at 10, 14·14,

or 20 inches from the screen; and the table is made out for every half-inch of the lens-scale. But inasmuch as we find that the improved arrangement of the mirror already referred to constitutes perhaps the most useful part of the instrument, and as the use of this improvement involves many alterations of D, Mr. Sennett, of the Kirby Street Engineering Works, Hatton Garden, the manufacturer of these instruments, as well as of our dynamometers, proposes in future not to furnish any table of values of L unless specially asked for it.

In these instruments we find that from 30 to 34 per cent. of the incident light at 45° is absorbed, whether this light is of ruby-red or signal-green colour, and practically none by the lens; so that we have the easy rough practical rule for all cases—add one-half to the measured intensity of light reflected. For more accurate working the exact absorption of the mirror of the particular instrument employed is used.

The intensity of the horizontal beam having been measured, the electric lamp is now raised or lowered and fixed in any position; a few seconds suffice to turn the mirror so that it sends its centre ray exactly through the centre of the lens. The distance from screen to mirror in this instrument being 22 inches, if δ is the distance from centre of mirror to vertical from lamp, and if θ is the angle of elevation, then

$$D = 22 + \delta \sec \theta.$$

Using this value of D in the formula above, and adding one-half to the strength of the light to make up for absorption, or making the more accurate correction for the special instrument employed, the true intensity of the light in standard candles can be ascertained. In practice, if an electric light is moderately steady, ten measurements may be made, with some confidence in their accuracy, in two minutes; and the light may be measured in ten different positions, from an angle of depression of 60° to an angle of elevation of 60°, 100 observations being taken, in less than half an hour.

We may mention one very important result we have been led to by the systematic employment of a photometer which can be used close to the electric light, and that is the large amount of

absorption that occurs on certain days when the rays from strong electric lights, and especially the green rays, pass through the air, which appears to the eye perfectly clear. At first we were inclined to think the higher results for the candle-power of a lamp obtained with our dispersion photometer than those obtained with an ordinary distance photometer were due to some error in our photometer itself; but we have since ascertained that this is due to the absorption of the air, because we find that, if simultaneous measurements are made with ordinary Rumford's photometers, each without lens or mirror, placed at different distances from the lamp in the same azimuth and in the same horizontal plane, the nearer one gives, as a rule, the highest readings, and the difference is the greater the stronger the light, and is greater if the light be examined at each photometer with green glass. The importance of such experiments in connection with the penetrating power of the electric light must be obvious.

13. *Electric-light Calculator.*

Having had occasion to make a large number of calculations of the illuminating power of various electric lamps, the horse-power electrically given to them, and the "efficiency" or number of candles per horse-power produced, we have devised, and had constructed, a simple piece of apparatus by means of which all the necessary calculations can at once be made, and which, after being used to work out the results obtained from any one experiment, preserves, until it is again used, a record of all the numbers employed in the previous calculations—an arrangement which serves as a valuable check in preventing clerical errors. The apparatus consists of four concentric discs graduated logarithmically, after the manner of the slide rule. The observed distance of the electric light from the photometer screen is sought for on scale 1; opposite this is brought the observed distance of the candle read off on scale 2, and the pointer shows at once the candle-power of the lamp. On scale 3 is read off the current in ampères passing through the lamp, and opposite this is brought the observed difference of potentials in volts between its terminals read off on scale 4, when the second pointer shows at once the horse-power electrically given to the lamp. Finally the illuminating power, as shown by the

first pointer, is brought opposite the horse-power, as shown by the second, when the number of candles per horse-power is at once read off.

14. *Coulombmeter.*

We have also, mainly for the purpose of experimenting on charging and discharging Faure's accumulators, arranged an apparatus which registers the total quantity of electricity that has passed through it in any previous given time—an apparatus, in fact, which acts for electricity as a gas meter acts for gas. This coulombmeter is simply a small magneto-electro-motor placed as a shunt to the main circuit, and acted on by *fluid friction,* which forms the essence of the apparatus, since such fluid friction opposes a resisting force directly proportional to the velocity, while, on the other hand, the force causing motion is proportional to the current; hence the current flowing is proportional to the velocity, and the total quantity of electricity that flows in any time is proportional to the total number of revolutions made by the motor in that time, and which are counted by an ordinary speed-counter attached to the revolving spindle. Hence the number of coulombs of electricity that have passed may be measured, by taking two readings of the counter, as easily as can the number of cubic feet of gas consumed by taking two readings of the gas meter.

This coulombmeter we have used for some time; but we have found this week that an instrument somewhat of this nature was patented some time back by Mr. Edison, although we are not aware that he has ever used it, or whether he realises the absolute necessity of the existence of a fluid friction. To him, however, we must yield up the priority of invention for this form of coulombmeter.

We have a strong current available, and we will now proceed to test experimentally all these various instruments which you see in the room before you, and which have been designed and constructed in each case to supply an actual need, which our experiments led us to see existed, for exact, portable, and moderately cheap measuring-instruments for use in electric lighting and electric transmission of power.

The PRESIDENT requested Dr. Obach to describe certain apparatus and diagrams which he had brought before the meeting at the request of the Council.

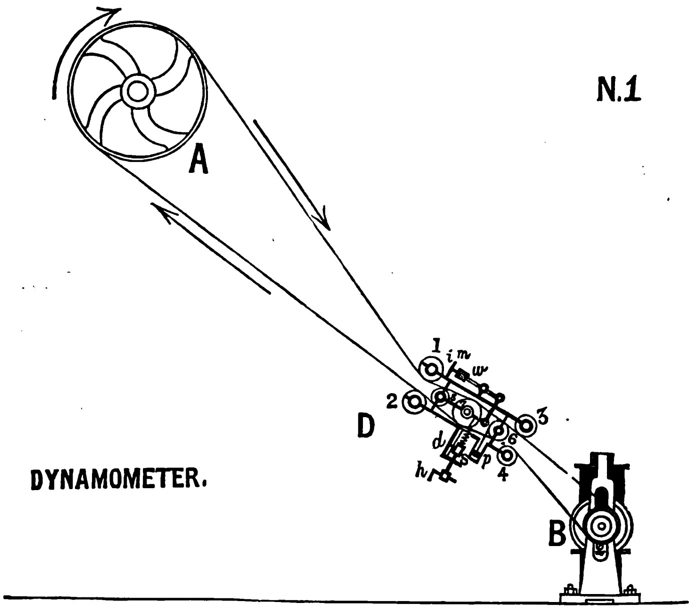
Dr. EUGEN OBACH: Mr. President and gentlemen,—The Council has been kind enough to allow me to say a few words on some of the measuring-instruments which are used by Messrs. Siemens Brothers & Co. for strong currents, as required for electric lighting, transmission of power, electro-chemical work, etc.

Perhaps a brief description of these instruments may not be entirely out of place to-night, as a sequel to Professors Ayrton and Perry's very interesting and valuable paper, which we have just had the pleasure of hearing.

Dynamometer.—The first instrument I should like to mention is a dynamometer used for measuring the power required to drive the machines which produce electric currents—for instance, dynamo-machines. The dynamometer which you see before you was designed by Mr. von Hefner-Alteneck, of Berlin, some time ago. A representation of it is given on Diagram No. 1. The instrument indicates the difference of tension of the two parts of the driving belt, viz., the driving side and the slack side. The strap connecting the driving pulley, A (which moves in the direction of the arrows), and the driven pulley, B, passes between six guide pulleys numbered 1 to 6. These are held in a fixed position by the framework shown in thick black lines; a seventh pulley, situated between the two parts of the belt, is held by a movable frame turning on the axis of No. 5. This frame and the pulley are counterbalanced in the different positions of the dynamometer, D, by means of a system of levers and an adjustable sliding weight, *w*. When the pressure on both sides of the movable pulley is equal, it stands in a central position, shown by the index, *i*, pointing to the mark *m*. If now the driving shaft is started, the greater strain on the driving side of the belt forces the movable pulley upwards, and in order to bring it back to the original positions the spiral spring, *s*, is stretched by means of a screw, *h*. The amount of stretching required is read off on a scale, *d*; usually one division of this scale corresponds to a difference of tension of one kilogramme. To obtain the power absorbed by the machine, the tension in kilo-

grammes must be multiplied by the circumferential velocity of the driven pulley in mètres per second. This figure will give the power in kilogrammètres per second, and dividing by 75 gives the horse-power.

The dynamometer is made in two sizes, the smaller for belts up to 3 inches wide and strains up to 50 kilogrammes; the larger size for belts up to 6 inches wide and a strain of 240 kilogrammes. If desirable, it can be fixed in an oblique position between the two



DYNAMOMETER.

pulleys, as shown in the diagram: it is readily tested by means of weights hung to a piece of strap, which passes between the pulleys on the driving side. The other end of this strap is fixed.

Electro-dynamometer.—I will now describe the electro-dynamometer which is used for measuring current strength. This instrument is standing on the table.

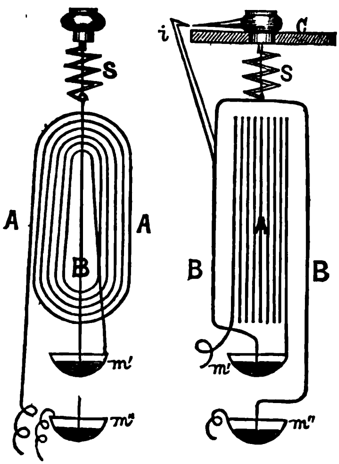
Diagram No. 2 shows the principle.

It consists of a fixed coil, A, having a number of convolutions,

and a movable coil, B, which in most instances is formed of a single turn of wire in order to make the influence of terrestrial magnetism as small as possible. The movable coil is suspended by a thread and a spiral spring, S; its zero position is at right angles to the fixed coil. If a current, which is led to the suspended wire by means of two mercury cups, *m′* and *m″*, is sent through the two coils in series, the movable one is deflected; by turning the top end of the spiral spring the coil is brought back to the original position, whereby the indicator, *i*, again points to zero. The angle

N. 2.

ELECTRODYNAMOMETER



through which the spiral must be turned is then read off on a circle, *c*, divided into degrees. Owing to the simultaneous increase of action in *both* coils with an increasing current, the angles of torsion are proportionate to the square of the current strength. This is precisely the power which is required for many technical calculations—for instance, the amount of heat or light produced, or the work given out or absorbed by a certain current. The instrument is supplied in three sizes, viz.,—

No. 1, with one fixed coil only for currents of ·5 to 2·5 ampères.

No. 2, with two different fixed coils for currents of 2·5 to 15, and 15 to 60 ampères.

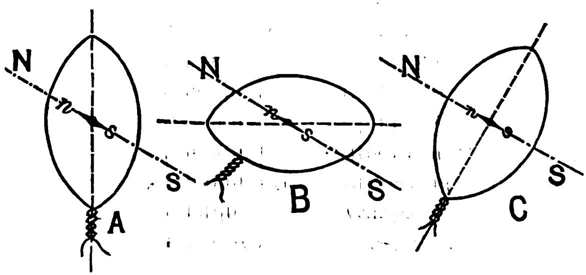
No. 3, with two different fixed coils for currents of 15 to 60, and 60 to 250 ampères.

A table is furnished with each electro-dynamometer, by means of which the current corresponding to each deflection is expressed in ampères. The instrument is equally suitable for alternating and for constant currents. It is but very little influenced by terrestrial magnetism or by currents passing in its neighbourhood. Each measurement takes but little time, as the index on the movable wire very quickly ceases to oscillate.

Movable Ring Galvanometer.—Another instrument for measuring the strength of powerful currents with great accuracy,

N. 3.

TANGENT GALVANOMETER



is one which I proposed a few years ago. It is a tangent galvanometer with a ring movable round a horizontal axis lying in the magnetic meridian. The instrument is on the table before you.

The principle can be explained best by reference to Diagram No. 3. If a small magnetic needle, freely movable in any direction, is suspended in the centre of a circular coil through which a current is passing, the following is observed:—If the current ring is in a vertical position, A, the needle is only acted upon by a couple which tends to turn it round a vertical axis: this is the case in the ordinary tangent galvanometer. The opposing force is the *horizontal* component of the earth's magnetism. If the ring is in the horizontal position, B, the needle

no longer leaves the meridian, but is merely turned round a horizontal axis or dipped. The opposing force is now the *vertical* magnetic component of the earth. For any intermediate position, C, of the ring between the vertical and the horizontal, the needle is at the same time deflected from the meridian, and more or less dipped. If by any means the needle is prevented from exercising the dipping motion, the instrument can be used for the measurement of currents of widely different strengths by placing the ring for each current in such a position that the needle is deflected to that part of the scale where the readings are most accurate, viz., near 45°. For any fixed position of the ring, the current strength is proportionate to the tangents of the deflections, as is the case with the vertical ring of the well-known tangent galvanometer. Table I. contains some measurements of a series, clearly showing that the law of tangents likewise holds good with the ring set at different inclinations. For these measurements, six currents of different strengths were compared at different inclinations of the ring. In all cases the same ratio was obtained for the six currents. If, on the other hand, the currents are compared by giving the ring in each case such an inclination that the needle always points to the same degree, say, for instance, 45°, 30°, 15°, then the *cosecant* of the angle between the ring and the *horizontal* plane determines the ratio of current strengths. These measurements are shown on the right hand part of Table I., under the heading "*cosecant measurements.*" If the angle between the ring and the *vertical* plane is measured, the *secant* takes the place of the cosecant. The table shows that the cosecant measurements give the same ratio for the six currents as that obtained by the tangent measurements; a check on the two methods of measurement is thus at hand.

If currents are compared at different inclinations, ρ, of the ring, giving at the same time different deflections, a, the tangent of the deflection divided by the sine of the corresponding inclination measures the current strength: thus, for three different current strengths,

$$S_1 : S_2 : S_3 = \frac{\tan. a_1}{\sin. \rho_1} : \frac{\tan. a_2}{\sin. \rho_2} : \frac{\tan. a_3}{\sin. \rho_3}$$

If the *same* current is measured at different inclinations, the fraction $\frac{\tan. \alpha}{\sin. \rho}$ must of course be a constant value, and this affords an excellent means of testing the degree of accuracy of the measurements through the entire range of the instrument. These means of controlling the results form an advantage which, as far as I know, is not shared by any other current-measuring instrument yet devised. Table II. gives some measurements which show no greater deviation of the different values of the constant from the mean than can be accounted for by slight variations in the battery power used for the measurements. The needle was formerly prevented from dipping by pivoting the axle at both ends in jewel bearings: this plan has lately been abandoned in favour of the following arrangement:—A small vertical axle, on which the needle is fixed, is provided with a little cylindrical leaden weight at the lower end. This adds but little to the momentum of the needle round the vertical axis, whereas a great power is required to lift it up by a dipping motion. The needle, with its aluminium pointer and the little weighted axle, is suspended by means of a cocoon fibre. This new arrangement has been found to answer very satisfactorily. There is not time now to touch upon some other improvements which have lately been introduced in the instrument, but after the meeting I shall be most happy to give further information to any member interested in the matter.

Tension Galvanometer.—The last instrument I should like to describe is the tension galvanometer used for measuring difference of potential or electro-motive force. One of Dr. Werner Siemens' bell-magnets is suspended between two coils of fine wire by means of a thread and spiral spring. If a current is sent through the coil the magnet is deflected, and it is then brought back to zero by turning the top end of the spiral, as we have seen in the case of the electro-dynamometer; but in the present instance the angles of torsion are proportionate simply to the current strength itself, because the magnet does not change its intensity with the current. Usually about 15 degrees correspond to an electro-motive force of 1 volt, and, if a

resistance is taken out by inserting a plug, to an electro-motive force of 0·1 volt.

The instrument which you see here has been designed for use with dynamo machines of low internal resistance and correspondingly low electro-motive force, such as are used for electro-depositing purposes. It measures, without the extra resistance (viz., with plug in), from ·007 to 1·15 volts, and with the extra resistance in circuit (viz., with plug out), from ·07 to 11·5 volts. In using the instrument two wires are led to the two points, the difference of potential of which is to be ascertained. The instrument can be placed at a great distance from the machine, as the resistance of the leads is almost immaterial, at least within the usual requirements. By using a stronger spiral spring, or a still higher resistance in circuit, instruments can be constructed on the same principle for much higher electro-motive forces. The use of a table facilitates the measurements by giving the electro-motive force direct in volts corresponding to the angles of torsion.

I must now close my remarks, which I am afraid have already taken up too much of your time, and in so doing I beg to thank you for your kind attention.

Measurements with the Moveable Ring Galvanometer.

TABLE No. I.

Current Strength.	Tangent Measurements.									Cosecant Measurements.						Mean Ratio from	
	Inclination ρ of Ring to the Horizontal Plane.									Constant Deflection.							
	$\rho = 90°$.			$\rho = 60°$.			$\rho = 30°$.			$\alpha = 45°$.			$\alpha = 30°$.				
	α.	Tan. α.	Ratio.	α.	Tan. α.	Ratio.	α.	Tan. α.	Ratio.	ρ.	Cosec. ρ.	Ratio.	ρ.	Cosec. ρ.	Ratio.	Tangent measurements	Cosecant measurements
S_1	68·9°	2·592	4·35	65·9°	2·236	4·30	52·2°	1·289	4·37	24·4°	2·421	4·36	14·2	4·077	4·34	4·34	4·35
S_2	64·1	2·059	3·45	60·15	1·743	3·35	45·75	1·027	3·48	31·1	1·936	3·49	17·9	3·254	3·46	3·43	3·47
S_3	59·05	1·668	2·80	55·05	1·431	2·75	39·25	·8171	2·77	39·5	1·572	2·83	22·3	2·635	2·81	2·77	2·82
S_4	51·2	1·244	2·09	46·8	1·065	2·05	31·8	·6200	2·10	60	1·155	2·08	30·8	1·958	2·08	2·08	2·08
S_5	38·85	·8055	1·35	35·15	·7041	1·35	21·95	·4030	1·36	—	—	—	49·9	1·307	1·39	1·36	1·39
S_6	30·8	·5961	1	27·5	·5206	1	16·45	·2953	1	—	—	—	—	—	—	1	—
S_1	68.8	2·578	4·33	65·95	2·241	4·31	51·7	1·266	4·29	24·6	2·402	4·32	14·4	4·021	4·27	4·31	4·30

TABLE No. II.

TANGENT-SINE MEASUREMENTS.

ρ	5·7°	11·5°	17·5°	23·55°	30°	36·9°	44·6°	53·1°	64·2°	90°
Sin. ρ	·1	·2	·3	·4	·5	·6	·7	·8	·9	1
α	6·9°	13·45°	19·8°	25·5°	30·85°	35·6°	39·7°	43·45°	46·8°	49·8°
Tan. α	·1210	·2392	·3600	·4770	·5973	·7186	·8302	·9147	1·065	1·183
$\frac{\text{Tan. }\alpha}{\text{Sin. }\rho}$	1·21	1·20	1·20	1·19	1·19	1·20	1·19	1·18	1·18	1·18

Mean of Constant $\frac{\text{Tan. }\alpha}{\text{Sin. }\rho} = 1·19.$

The PRESIDENT: It must be obvious to the meeting that the hour is now too late for us to have the pleasure of hearing the other paper promised to us by Professors Ayrton and Perry, though a few minutes may still be devoted to the remarks any gentleman present may wish to make upon what we have just heard. I am sure that the meeting will be very much pleased if Dr. Fleeming Jenkin will favour us with a few remarks.

Professor FLEEMING JENKIN: I am sorry that I have no remark to make worth offering, but I am glad to have the opportunity of expressing my regret that I should have been so long absent from the meetings of the Society. When I heard the two excellent papers which have been read to-night, I felt that no electrician could be long absent from this Institution without falling behind the times.

Mr. C. V. BOYS: I would remark, in reference to the current measurer described by Professor Ayrton,—in which a needle is acted on by a current alone, and in which no magnets are placed,—that a similar galvanometer was, I think, hinted at by me in a paper read before the Physical Society in November last. It is true that I have not made an instrument of the kind, but I think I showed the principle on which one could be made. I thought the fact was just worth mentioning. The electric-energy meter, or electrical-power meter, of which I have lately published a description, is also on the same principle as the one which Professor Ayrton has described—the combination of the principal current and the shunt current; but it, I think, in consequence of the very great amount of force which can be obtained from the instrument, is the only one that is capable of actuating any kind of integrating apparatus, so as to make a machine which will give the total amount of energy that has been expended during any length of time. I do not know whether the electro-dynamometer would give sufficient power to work an integrator or not.

I should like to ask Professors Ayrton and Perry one question with regard to the rotary electric-current meter, as to whether there are sliding contacts of any kind between the terminals of the instrument. If there are (and I suppose the case of an instrument

which goes without attention), and anything happens through their wear and tear or their becoming dirty, it is perfectly obvious that they would thereby introduce an uncertain, and possibly a great resistance, in the path of the current being measured, and so cause inaccuracy in the readings.

Mr. J. E. H. GORDON: Sir, there is one point in Professors Ayrton and Perry's instruments to which attention has not, I think, been sufficiently directed, although it appears to me to have great merit—I mean, that the instruments are absolutely "dead-beat." I have found by experience that the instruments will show very rapid changes. In the case of many other instruments which are otherwise very good, their sluggishness prevents them indicating a sudden change in the thing to be measured until the change is over, and hence all record of the amount of such change is lost; whereas with Professors Ayrton and Perry's apparatus the magnitude of even a very sudden change is accurately recorded.

Professor W. E. AYRTON, F.R.S., in reply, said: I am sure I am very pleased to hear the remarks made by the various speakers. In regard to the iron needle without a controlling permanent magnet, referred to by Mr. Boys, I would say that both Professor Perry and myself were quite unaware that such an arrangement had been suggested by him; we have certainly never read any description of it, nor seen any instrument made on this principle prior to our own.

As to the use of the two coils, one acting on the other, I may mention that this instrument in its embryo form was published by us at the commencement of 1881. Therefore, I think, we cannot be accused of adopting this principle at all lately. The improvements effected by the employment of the wheel and pinion, by means of which we obtain a deflection of the pointer through 360°, is also, we believe, quite novel.

As to Mr. Boys' question, whether inconvenience could arise from the varying resistance of the sliding contacts, the answer is, No, because the instrument is only a shunt to the main circuit: the resistance of the portion of wire through which the main current flows is but a very small fraction of the coulombmeter itself, so that any variation of resistance in the shunt from any

cause, that is in the coulombmeter itself, would not affect the main current.

Mr. Gordon rightly mentioned one of the main points we had in view in devising our apparatus. I would not for a moment be considered as depreciating the admirable instruments described to us by Dr. Obach this evening (to which we attempted to give credit last year, when bringing our apparatus for the first time before this Society), but there are certain (I think I may be allowed to say so) very serious objections in them. One is that they are not dead-beat: the needle swings for a long time before a reading can be taken, on account of its very large moment of inertia. The question of dead-beatness is one we have given a great deal of attention to in making these instruments. We have insisted on having an excessively small moment of inertia. Our pointers are made of aluminium, corrugated to give stiffness, and are very thin (indeed so thin that the maker seriously objects to using so delicate a pointer), and by this arrangement we obtain the greatest amount of stiffness with the smallest moment of inertia. As an illustration of the dead-beat character of the instrument, I have often been able to tell the number of revolutions in the engine by observing the quick, regular flickers of the needle caused by the belt joint passing round the dynamo machine. Further, all our instruments are so constructed that the straight-line law is fulfilled—that is, the deflections, even the large deflections of 200° or 300°, are directly proportional to the thing measured. Another objection that our ammeters and voltmeters, for example, do not possess is, that they are not disturbed by the presence of powerful magnets, and even may be placed near a dynamo machine; also the needle is so accurately balanced that no alteration takes place, no matter what be the position in which the instrument is held.

Another point that is also essential in a workshop instrument is that the movable part shall not be exposed to the air and liable to be blown about, as is the case in some of the instruments described by Dr. Obach. In fine, the instrument must be dead-beat, it must be possible to put it near a powerful magnet without disturbing the indications, it must be able to be used in any position, and of course a puff of air must not act on it.

It is important to remind users of instruments for reverse currents, that instruments which are commonly said to measure reverse currents do not really do so: they measure the square root of the mean square of the current, which is not the current. The square root of the mean square of a set of things is not the mean of those things. There is one use of the ohmmeter to which I did not give sufficient attention, viz., that by it all so-called resistance coils may be dispensed with in electric light experiments, and the resistance of any part of the circuit can be measured while a current is flowing. All kinds of coils and devices have been tried in order to prevent the alteration of resistance due to heating. We say, put them all on one side, take up any piece of wire you like and use it as your resistance coil; take a bit of carbon, a wet rope, a pail of water, or anything that is convenient, and when you use it measure its resistance at the moment that the strong current is flowing.

The PRESIDENT: After the very interesting papers that we have heard, the meeting will very much regret that there is not time to hear the second paper which was down for this evening by Professor Ayrton. It is tco late for me to ask gentlemen present to propose and second in the usual way a vote of thanks to the gentlemen who have been before us this evening, and I believe I shall have the unanimous approval of the meeting when I ask for the vote of thanks to them.

At our last meeting I announced that it was the intention of the Council to ask Mr. Stroh to repeat his beautiful and interesting experiments, and the explanation which then he gave us. You will be glad to hear that Mr. Stroh has kindly consented to do so; and I have therefore to announce, that there will be an Extraordinary Meeting of the Society on this day week, on which occasion Mr. Stroh will repeat his experiments, and his explanation of the "Attraction and Repulsion due to Sonorous Vibrations, and a Comparison of the Phenomena with those of Magnetism."

A ballot took place, at which the following were elected :—

As Member:

Henry Moors.

As Associates:

William Philip Beckervaise.
Thomas Boulting.
William B. Campbell.
Enrico Conti.
Frederick William Cooke.
James Fisher.
Arthur Edward Gilbert.
Sydney James.
Robert Ellis Joseph.
Robert L. McCann.
F. McLean.
J. Orme.
Edward Penton, junior.
Francis Shenton.
W. Slingo.
Lieut. H. E. Tyler, R.E.

As Students:

Charles McCarthy.
J. L. Shadwell.

The meeting then adjourned until Thursday, May 18th, 1882.

An Extraordinary General Meeting of the Society was held at the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday evening, May 18th, 1882—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the last meeting were read and confirmed, and the names of new candidates were announced and suspended.

The SECRETARY announced that a donation to the library had been received from M. F. Delarge, Local Honorary Secretary to the Society for Belgium.

The PRESIDENT: Those who were present at our last meeting will remember that the time was so much occupied by the first paper, that the second paper by Professors Ayrton and Perry, announced for the same evening, on "The Technical Education of an Electrical Engineer," was not read. It will remain for the Council to decide when Professor Ayrton will be asked to lay that paper before us, but it cannot be at present, on account of the approaching close of the session.

I will now call upon Mr. Stroh to be good enough to repeat the paper which we heard this day four weeks, and to the repetition of which he so kindly assented at the request of the Council.

Mr. A. STROH then repeated and explained his experiments in connection with "Attraction and Repulsion due to Sonorous Vibrations, comparing the Phenomena with those of Magnetism." He concluded by saying:—

On the last occasion when I had the honour to read my paper, several gentlemen asked questions which the lateness of the hour prevented my answering, and I consider it therefore my first duty to do so now. Professor Guthrie's question as to whether *attraction* were changed into *repulsion* by the removal of one of the vibrating membranes to the extent of half a wave length, is one to which I gave some attention at the commencement of my research. It is perfectly reasonable to expect such an effect, and I have alluded to it in my paper, but being at the time in search of other effects, I did not further pursue my investigation in that direction.

Mr. Preece was quite right in suggesting that two membranes standing opposite each other and vibrating in opposition to one

another, as shown in Fig. 8 of my paper, might be said to be in *opposite* phase, instead of being in the *same* phase, as I have described; but I think we must in these experiments look upon the *effect* more than the *cause*, and when both membranes produce simultaneously alternate compression and rarefaction of the air near them, whatever be their position towards each other, we must look upon the vibrations as being in the *same* or *like* phase, with regard to the medium between them.

I understand that Mr. Preece's suggestion arose from the desire to make the analogy between the two sets of experiments *perfect*, but the last experiment described in my paper (see Figs. 36, 37, and 38) shows that this cannot be done.

In this experiment, which I consider an important one, for in it two effects are combined, the little disc (Fig. 36) places itself *parallel* with the axes of the drums, whose membranes are vibrating in like phase (Fig. 37*a*), while it turns at *right angles* to the axes between two similar poles of magnets. In both cases it is *repelled* from the central or axial position.

Were we now to reverse the order of things and call the phase of vibration of two membranes, as represented in Fig. 37*b*, the *same* or *like* phase, and compare it with two similar poles of magnets, then we should obtain certainly a position of the disc at right angles to the axes of drums or poles in *both* cases; but, between the vibrating membranes, it would be *attracted* towards the axial position, while, between magnetic poles, it would be *repelled* from the axes of the poles towards the position XX, Fig. 38*a*. Therefore, by setting one difference right, another would appear, and the change of terms would not help us in any way.

Professor Foster asked, very pertinently, what would take place when the phase of vibration of the two membranes was neither the *same* nor *opposite*, but *quarter* phase. My apparatus, as at present constructed, does not admit of the production of this effect, but I have not the slightest doubt that, in the case mentioned by Professor Foster, there would be neither *attraction* nor *repulsion*.

All the experiments described in my paper, and which I have shown this evening, are such as can be compared with correspond-

ing magnetic experiments; but there are others which will not compare with magnetism, and which are nevertheless interesting in connection with the investigation.

For instance, I have shown by the two card-board discs, represented in Fig. 25 of my paper, that we obtain apparent *attraction*, caused probably by the momentum of the expelled air creating a partial vacuum as described; but, if by some means or other I prevent this momentum taking place, say by placing a flange or rim round the disc (shown in Fig. 39), the conditions are entirely

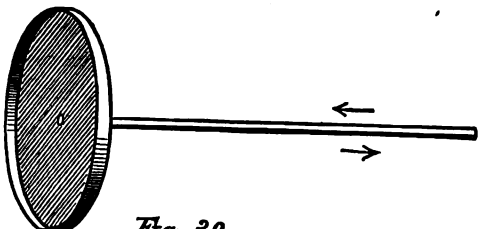


Fig. 39.

altered. If I move such a disc with a flange to and fro in front of a suspended disc, in the manner described in the experiment Fig. 25, we obtain *repulsion*, while as soon as I remove the flange from the disc we have *attraction* again, as before.

This experiment may be varied by taking a piece of brass tubing of about 9 centimètres in diameter, and about 7 or 8 in length, into which fits loosely a wooden piston with a rod, as shown in Fig. 40, and presenting one end of the tube to the suspended

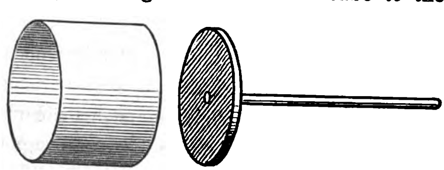


Fig. 40.

disc (Fig. 25) while moving the piston within the tube to and fro, then the tube acts in a similar manner as the rim or flange in the previous experiment, and *repulsion* is the result; but by placing a flange or disc of about 14 centimètres in diameter, as shown in

Fig. 41, on the end of the tube which is presented to the suspended disc, *attraction* is again obtained. It is worth noticing that the flange in this experiment forms a flat surface at *right angles* to the axis of the tube or the piston rod, while in Fig. 39, where the *opposite* effect is obtained, the surface of the flange is *parallel* with axis or rod.

A similar experiment may be made with the drum and vibrating membrane. We have seen that a single vibrating membrane will attract a disc, D, Fig. 12, but when a short piece of tube is placed over the drum, so that the end of the tube projects beyond the drum and membrane to the extent of a few millimètres, as shown in Fig. 42, *repulsion* of the disc D is the result, while a

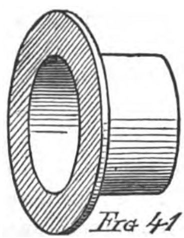


FIG. 41

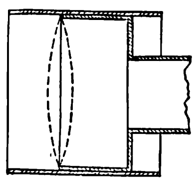


FIG. 42.

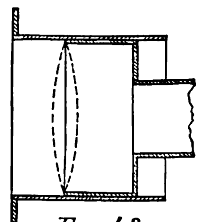


FIG. 43.

little flange of three millimètres in depth (shown in Fig. 43), when placed on the end of the tube, will have the effect of converting the repulsion into *attraction* again, as before.

I may be excused here for indulging in a little speculation, viz :—We are all aware that there is no substance known at present which will insulate magnetism, or, in other words, which the magnetic lines of force will not completely penetrate. If we had, however, such a substance, and were able to make a tube of it, and place it over the pole of a magnet, in the manner shown with the drum, and thereby cause the lines of magnetic force to be altered or diverted into a different direction, *perhaps* (and I only venture to go so far as to say *perhaps*) we should obtain similar results with a magnet as those I have just shown with the disc and the vibrating membrane.

The PRESIDENT: We have almost quite reached the limit of our usual time, and we rarely extend these meetings past ten

o'clock. On this occasion no doubt there are many gentlemen present who would like to say a few words. I refrain from asking them to do so, because, probably the meeting would be too much prolonged. I will therefore ask Professor Adams to be so kind as to propose a vote of thanks to the lecturer.

Professor W. G. ADAMS, F.R.S. : I have very great pleasure, Sir, in rising at your request to propose a vote of thanks to Mr. Stroh for his very interesting paper. I have no doubt that I am expressing the opinions of all present when I say that we have been very much interested in these beautiful and delicate experiments of Mr. Stroh's, and every one must admire the complete way in which he has carried them out. We know well that Mr. Stroh is always exceedingly clever in carrying out experiments to illustrate any subject that he takes in hand, and to-night he has quite succeeded, and has given beautiful illustrations of vortex motion in liquids and in gases. He has shown us the complete analogy between the motions of gases and the motions of liquids, as shown by the experiments of Professor Bjerknes (which many of us had the pleasure of seeing last year in Paris), when they are set in motion by vibrating discs. He has shown us also the close analogy between the motion of such vibrating discs in the presence of liquids or gases, and the motion of a magnetic needle in a magnetic field. I would like to make a few remarks with reference to the cause of these apparent attractions and repulsions of the vibrating discs in Mr. Stroh and Professor Bjerknes' experiments, and to draw attention to the relation which these experiments have to the beautiful experiments of Mr. Froude, whereby he proved some years ago that, when a fluid is in motion, but with different velocities in different parts, the whole amount of energy of motion of the fluid being a constant quantity, where the velocity is greatest the pressure of the fluid is least.

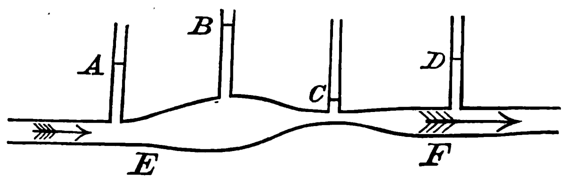
From the principles of conservation of energy, we should expect that, in a fluid in motion, if part of the energy is spent in increasing the velocity of the moving particles, there must be less potential energy or diminished pressure.

Mr. Froude showed this experimentally, by allowing a stream of water to flow through a pipe of varying diameter in different

parts. Where the pipe was contracted, and therefore the velocity of flow increased, the pressure was diminished, and where the pipe was largest, there the velocity of flow was least, and the pressure was greatest.

Thus, if E F be a pipe through which a liquid is kept continually flowing, and if tubes A, B, C, D be inserted at various points, the height of the liquid in these tubes will indicate the pressures at the several points, and these heights will be found to be least where the pipe is smallest, *i.e.*, where the velocity is greatest.

Now let us see what bearing this principle has on Mr. Stroh's experiments. If we take the case of the vibrating disc, which is attracted when the back of the hand or a disc not in vibration is presented to it, immediately in front of the centre of the disc,



the changes of velocity of motion of the fluid are the greatest, and the mean square of the velocities has its greatest value, and hence the average pressure in this position is less than in other parts of the fluid.

In going out from the centre of the disc in any direction, the average velocity diminishes, and, as the energy of motion depends upon the square of the velocity, and will therefore be the same whether the motion be backwards or forwards, the average pressure will gradually increase until we reach that portion of the fluid which is not in vibration. The external pressure on the tube and support of the disc being greater than the pressure immediately in front of the disc, the disc will move forward.

Take, again, the case of attraction of discs at the ends of two tubes placed opposite to one another, and both vibrating inwards or both outwards at the same instant (discs which Mr. Stroh describes as being in the same phase). In this case, in the experi-

ment with glycerine and a coloured liquid, we saw (and I hope members noticed this point in the experiment) that the vortices were moving with different velocities in different parts of the four quadrants in which the symmetrical states of motion were set up. The velocities were greatest immediately in front of the discs where the threads of coloured liquid became suddenly drawn out, and hence we should expect that these were positions of least pressure, and that the resultant pressure in front of the discs is less than behind them, and consequently the discs will move towards one another. The thread of coloured liquid came slowly up along the face of the disc towards the centre, and the velocity gradually increased to its greatest value as the thread bent round to move in a direction perpendicular to the faces of the discs—outwards. In this central position, then, the pressure reached its least value, and the resultant pressure of the surrounding liquid caused the discs to move towards one another.

I must not trespass on your time by discussing the other experiments, but they are most beautiful illustrations of the theory of the motion of liquids and gases.

If there were any liquid or any substance by the vortex motions in which we could suppose magnetic effects to take place, then we should have a most complete analogy between these motions and the action of magnetic poles on one another.

In the case of gases, I apprehend that the cause is the same as in the case of liquids, that in fact the result has more to do with the actual motion of the gas than the change of density taking place in the gas itself, although both conditions of course are present.

At this late hour, I cannot detain you any longer, but I have very great pleasure in proposing a vote of thanks to Mr. Stroh.

Mr. W. H. PREECE, F.R.S.: I have very great pleasure in seconding the proposal of Professor Adams, that we accord a vote of thanks to Mr. Stroh for the entertainment and enjoyment we have received to-night. In the earlier part of the evening he produced an experiment which, in a kind of roundabout way, reminded me of a reply once made by Mr. George Stephenson to a question asked of him as to what was the greatest power in this world?

Stephenson replied, "The eye of the girl we love, because let it be wherever it may, even at the antipodes, it would attract us there." Now, if he had said the *voice* of the girl he loved, I think he would have been more near the mark, because we do not so much go to the other side of the world to see the eye as to hear the voice. Now, Mr. Stroh to-night gave us evidences of this power in two ways. He showed us, first of all, how his own voice was a power of attraction in keeping so large an assembly as this for nearly two hours, wrapped in following the beauty of his experiments, and the clearness and simplicity of his explanations; and in the next place he produced an experiment that none of us had ever seen before, and most of us have sometimes heard of, viz., the attraction of our own voice. We know there are many men in this world who are very fond of hearing themselves speak, and therefore we may assume that they have a certain amount of attraction in their own voices; but to-night Mr. Stroh was able, by the power of his own voice, to produce the attraction of two solid atoms of matter towards each other. What with that experiment, which was something new, and what with the additions he has given us to the paper he read before, we all of us must feel this, that whatever pleasure we experienced when we heard his discourse three weeks ago, that pleasure was doubly enhanced to-night by the additional completeness of the beautiful experiments he showed.

The PRESIDENT: As the meeting is so unanimous on the proposal which has been made and seconded, it is unnecessary for me to put it to the meeting as a vote. I think we may accept that the proposal has been put and carried unanimously, with applause.

I beg to announce that the next ordinary meeting of the Society will be held on the 25th May, 1882. The subjects that will be brought before that meeting, are—"On a New Method of Determining Large Electric Currents and very Low Resistances," by Lieut. P. Cardew, R.E.; and "The Organisation and Operation of the Field Telegraph Corps in the Transvaal in 1881, with some General Remarks on Field Telegraphs," by Lieutenant A. W. Bagnold, R.E.

The meeting then adjourned.

The One Hundred and Fourteenth Ordinary General Meeting of the Society was held at the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday evening, May 25th, 1882—Lieut.-Col. C. E. WEBBER, R.E., President, in the Chair.

The minutes of the Extraordinary Meeting held on May 18th were read and confirmed, and the names of new candidates were announced and suspended for ballot at the close of the proceedings of the present meeting.

The PRESIDENT: I have now to announce to the meeting, that the Council have decided that the Society shall offer three premiums annually for the best three original papers sent in to the Council, on telegraphs or electrical subjects, during one session, by any person not being a Member of Council to the Society.

The first premium will be called the Society's Premium, and will be of the value of £10; the second will be called the Paris Electrical Exhibition Premium, of the value of £5; and the third will be called the Fahie Premium, of the value of £5, being the annual interest of a sum of money presented to the Society a few years ago by Mr. J. J. Fahie, of India.

The awarding of the premiums will rest with the Council, who will have the power of declining to award either or all of the said premiums in any year in which they may consider the papers offered as unworthy of the prize.

The premium will consist of books or scientific apparatus. No person will be entitled to receive more than one of the premiums in any one year. The first premiums will be awarded in 1883, for the best papers sent in between this date and the end of May next. I will now call upon Lieut. P. Cardew, R.E., for his paper.

The following paper was then read:—

ON A NEW METHOD OF DETERMINING LARGE ELECTRIC CURRENTS AND VERY LOW RESISTANCES.

By LIEUT. P. CARDEW, R.E.

Mr. President and gentlemen,—In asking your attention to the subject of this paper, I am conscious that it has the misfortune of

closely succeeding that by Professors Ayrton and Perry on the same subject.

I need hardly say that, if the choice of date had rested with me, I should have followed such leaders at a more respectful distance. When I was, to use a military expression, put in orders to produce a paper, by our distinguished President, and selected this subject, I was, of course, unaware that the ground would be so formidably occupied, and I understand that there has been great difficulty this season in arranging for the number of papers sent in, so that the unfortunate position of mine was unavoidable. However, as I am to be relieved by a brother officer who can tell us of real work done under no ordinary difficulties, you will at any rate have some return for your attendance.

Perhaps the title of my paper requires some apology. I am aware that an eminent scientist has discovered that there is nothing new under the sun, and I dare say the method I am about to describe has, if there be anything in it, been known to many. But I hope it may be new to some at least here, as its novelty is my only excuse for bringing it forward.

The ordinary measurement of current by the galvanometer consists essentially in comparing the effect produced by the current on the needle with that produced on it by a known current, or one in which the electro-motive force acting is known or determined, and also the resistance through which it is acting. The absolute determination of current by its effect on a suspended magnet or current is not at present a practical operation.

The determination of any electro-motive force for the purpose of arriving at the value of the current used for obtaining the constant of the galvanometer, as it is called, always eventually involves taking the electro-motive force of some standard cell as a starting point, and also the correct determination of some resistance.

This is equally true of measurements of current with the ordinary form of electrometer.

The constant, or value of the deflections, of any form of galvanometer is liable to changes from several well-known causes, and for accurate measurements requires to be taken before and after each series of measurements—a laborious operation, in which, unless great care is taken, errors will certainly arise.

Even with every precaution an accidental alteration of the magnetic field, while operating, may produce grave errors.

In addition to the difficulty introduced by the constant, there is, in most forms of galvanometer, considerable difficulty in reading accurately; and to give good results the deflections must lie between 20° and 60°, which only allows a limited range of currents to be measured.

If, however, we take a delicately-pivoted or suspended needle, and surround it with two coils, through one of which we pass the current to be measured, and through the other a current of known strength, so as to oppose the other current in its effect on the needle, and if under these circumstances the needle remains at zero, there must be a definite relation between these two currents, depending on the position and number of turns of each coil.

If one of the currents is a strong current and the other a weak one, the strong current must be passed round fewer times and at a greater distance than the weak one.

When the relation existing between the two currents has been found, which can be easily done, we have obviously a means of measuring any unknown current, of sufficient intensity to affect the needle, by balancing it with a current of known intensity passed from a constant cell or cells through the balancing coil of the galvanometer and a rheostat in which the resistance is altered until the balance is effected, and the instrument can be constructed so that a very small current will balance a very large one.

In order to arrive at the constant relation between the coils, they should be connected, with added resistances to each, to two points between which a difference of potential is maintained, and the resistance in one circuit altered until the balance is obtained. This balance will be quite independent of the amount of difference of potential and of any variation in it. I have obtained the same constant with one Lechanché cell and with the current from two Siemens dynamos. Of course, the larger the difference of potential or currents flowing, the more perfectly the constant can be obtained, provided that the resistances employed are such as will not heat.

If $V-V^1$ be the difference of potential, r the resistance of the

galvanometer coil through which the large current is flowing, w the added resistance in this circuit, R the resistance of the galvanometer coil through which the small current is flowing, W the added resistance in this circuit, the currents flowing will be, $\frac{V - V^1}{r + w}$ through the thick coil, $\frac{V - V^1}{R+W}$ through the fine coil, and these are to one another reciprocally as the resistances, or the constant or number by which the small known current must be multiplied to give the large unknown one is $\frac{R+W}{r+w}$.

In order to try this method, I took a large Obach galvanometer, consisting of a magnet pivoted in the centre of a large brass ring forming the conductor, which can be inclined so that its plane makes any angle with the horizontal plane of motion of the needle. I removed the magnet and its pivot, and in its place substituted one of the common astatic galvanometers, replacing the upper magnet of the astatic with a brass pointer.

Thus I had a magnet very close to a high resistance coil and in the centre of a large conductor. I found the constant of this, by the method described, to be very nearly 24,000. It came the same whether taken with a single large cell or a current of 60 ampères, and was also tried with varying resistances in the circuit of the large conductor. The true resistance in each circuit was accurately obtained by balance in each case, and of course proper precautions were taken to prevent heating, by making short contacts and using large wire, and in the case of the large currents special forms of resistances.

The constant was found to be only true when the needle was nearly at zero; if it was allowed to swing more into the galvanometer coils the constant was altered. To prevent this, I placed stops on each side of the needle near the zero mark.

I also tested the permanence of the constant by causing the difference of potential to which the ends of the two circuits were connected to vary considerably after the balance had been obtained, and without varying the resistances. This never produced the least effect on the needle.

Having satisfied myself as to the correct determination of the constant, I used the instrument to measure various currents, some

from a Grove's battery, and others from dynamo machines, at the same time measuring the currents by means of one of Sir W. Thomson's best forms of electrometer connected to the two ends of some resistances supplied by Messrs. Siemens, especially designed to take very large currents without heating. These resistances were also connected in divided circuit for the large currents. I have put a few of the results on the board.

These results are not accidental, but I am confident of being always able to reproduce them.

I should state, however, that the electro-motive force of the battery used to balance the large current was always tested on the electrometer, and the resistance in its circuit carefully balanced after each determination, as the object was to test the principle. I do not mean to imply that in ordinary work the results would be as near absolute measure as these are.

In the first place, of course, the resistance, and therefore the currents in the balancing circuit, would depend on the temperature, and allowance must be made for this if accuracy be aimed at.

The electro-motive force of the battery is also, of course, subject to some variation. The battery I employed was one large Daniell cell for the small currents, and three for the large ones.

Since all methods of measuring currents ultimately depend on the determination of the electro-motive force of a standard cell, variations in this are unavoidable errors, and I think it probable that the electro-motive force of a large Daniell cell passing a current through a high resistance, as in this case, is as little subject to variation as that of any other cell, even if measured statically.

I shall be very glad to hear of any cell better suited to the purpose. Of course the resistance of the cell itself must either be negligible in comparison with the external resistance, or constant within negligible limits.

It will be seen at once in what lies the advantage of this method of measuring currents.

We have a needle which may, if desired, be made so sensitive as to be visibly deflected by a current of $\frac{1}{5000000}$ in the balancing coil kept in the zero position, when a current which may be at least $\frac{1}{1000}$ without injury to this coil is passing through

it. Thus the slightest alteration in the current must be immediately felt. In fact it has the same advantage over the method of measuring current by the deflection of a needle that null methods of measuring resistance have over other methods.

The vibrations of the needle produced by varying currents, such as when a lamp is in circuit, can be checked by stops, and also, if desired, by means of a paddle dipping in a liquid.

There is one precaution which is very necessary in using this method, which is to ascertain that, with large currents, the leads in the neighbourhood of the galvanometer do not exert any appreciable force on the needle.

In order to insure this, the terminals must be placed where the least effect will be produced, and it is further necessary to have a means of placing a short circuit between the terminals, and then of breaking the continuity of the circuit for the large current through the galvanometer. Short-circuiting alone obviously will not do.

Should any deflection be observed in the needle when this has been done, the leads must be manipulated until the deflection is reduced to nothing. The circuit can then be completed, and afterwards the short-circuiting plug removed.

The process of measuring very low resistances, such as those of large copper wires, by this method, is the same as for obtaining the constant.

The unknown resistance is connected to the large conductor of the galvanometer, and the balancing-coil with rheostat is connected in divided circuit to these. A sufficiently large current is then passed through the system to influence the needle, and the resistance in the rheostat altered until the balance is obtained, when we have the following equation:—

$$\frac{V - V^1}{r + x} = \frac{V - V^1}{R + W} \times c,$$

or

$$x = \frac{R + W}{c} - r,$$

where x is the unknown resistance, R that of balancing coil, W that in rheostat, r that of large conductor, and c the constant previously obtained. r can be made so small as to be

negligible, or R + W may be made so large, as compared with x, that V and V^1 can be taken at the ends of x, and the current through x taken as the whole current measured on the large coil.

In order to obtain by this method a measure of a very small resistance, it is evident that c must be large as compared with R.

In the modified Obach galvanometer, C was 24,000, R 1,000, thus giving me a power of balancing to $\frac{1}{24}$ of an ohm.

This was not low enough for the purpose required, as I wished to possess the power of directly balancing $\frac{1}{100}$ of an ohm at least.

The Obach galvanometer, also, did not possess any means of short-circuiting the coil, and then breaking the continuity of the coil, keeping the current passing through the leads, and the terminals were not sufficiently good to ensure no resistance being introduced at the contacts.

I therefore had this galvanometer constructed.

This consists of a board on which are fastened large copper straps to form two separate conductors, one passing underneath the bobbin, the other at three inches from it. The transverse straps are both connected at one end to a longitudinal strap, the other ends being separate, and all the ends are led to these mercury cups, by which perfect contact is readily secured.

The mercury cups also afford an easy means of testing the disposition of the leads by short-circuiting, and then breaking the continuity of the galvanometer.

It will be observed that all the conductors for the large currents have one end in connection with this left-hand strap and mercury cup, connected by this movable piece to another mercury cup in which the lead is placed. The cups are of such a height that these pieces of copper wire when put across to short-circuit the galvanometer are at the same level as the needle, and consequently the current through the piece of wire exerts no effect on the needle.

For travelling, the cups can be readily emptied by means of these holes and pegs, and the mercury carried in a bottle. I much prefer mercury cups to ordinary terminals when electric light currents have to be manipulated.

The bobbin is rectangular, with the ordinary form of magnet

pivoted in the centre, and a light pointer at right angles to the magnet.

On the bobbin is wound, first, a coil of fine wire of 355 ohms resistance. This is covered over with strips of ebonite, and then brass pieces are screwed across the bobbin to take the thick wire on top.

The thick coil consists of No. 14 wire, 10 feet in length: one end of it is connected to the strap passing underneath, the other is brought to this mercury cup.

These two terminals are the ends of the fine coil.

It would be perhaps simpler to have the rheostat also on the board and permanently connected, but a really suitable rheostat has not yet been procured.

The constant of the No. 14 wire coil has been determined to be approximately 348, of the strip of copper underneath the bobbin to be 8,336, and of the strip 3 inches from the centre of the bobbin to be 58,220.

With these three conductors and one cell alone in the balancing coil, we have the means of balancing currents from $\frac{1}{100}$ ampère to 170 ampères nearly.

The lower limit is determined by the smallest current which will produce a good deflection through the coil of 355 ohms, using the No. 14 wire coil for the unknown current; the upper by the current which passed through the most feeble conductor balances a current of $\frac{1 \cdot 07}{355}$ through the high resistance coil.

Larger currents could be balanced by using more cells.

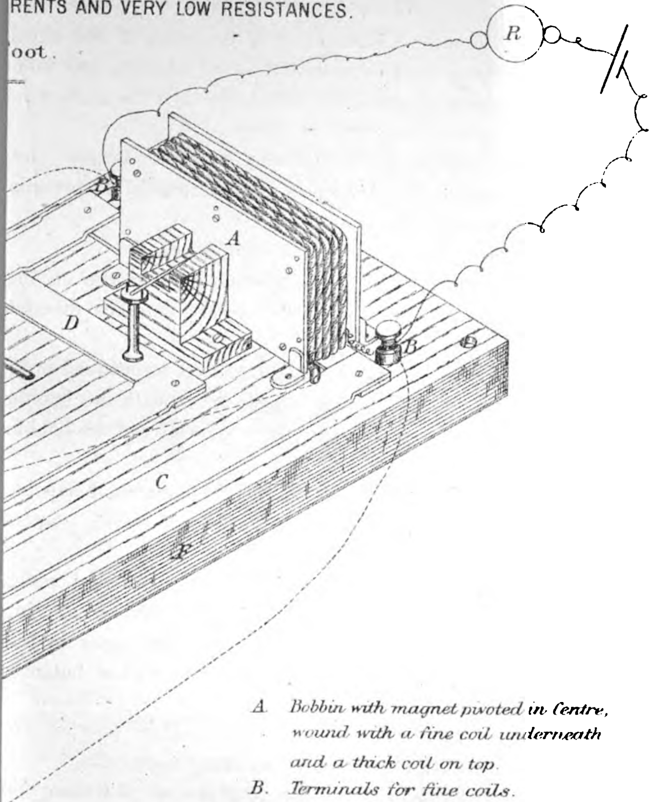
For measuring resistances we can go as low as ·006 ohm, and the resistance of the galvanometer is something very much lower than that.

All that is required is to connect up as marked on the instrument, taking the precaution of testing for the proper disposition of leads by short-circuiting the galvanometer by one of these copper bars, and breaking the connection by removing this bar.

Unless the unknown current is known not to exceed one ampère, it will be better to begin with one of the large conductors in circuit, so as to avoid heating.

RENTS AND VERY LOW RESISTANCES.

oot.



A. *Bobbin with magnet pivoted in Centre, wound with a fine coil underneath and a thick coil on top.*

B. *Terminals for fine coils.*

C. *Large Conductor passing underneath bobbin.*

D. *Large Conductor 3" from magnet horizontal.*

E. *Mercury Cups.*

F. *Wood base.*

G. *Bent Copper wire for breaking Connection.*

H. *Bent Copper wire for short Circulᵗⁿᵍ.*

When the currents are on, observe whether the needle points to "increase" or "diminish," and turn the rheostat accordingly. When the balance is obtained, add to it 355 for the resistance of the galvanometer, and divide the constant multiplied by 1·07, if a Daniell's cell has been used, by this sum.

For great accuracy, of course the percentage of increase or decrease in resistance for temperature must be allowed for.

This operation appears to me quite as simple as the ordinary determination of resistances, but I am told that it will involve too much trouble for the electrical engineers of the present day to take, and that they will not look at an instrument in which the webers, or ampères, are not marked off on a scale.

I have therefore designed this instrument on the same principle, which will, I hope, meet their views. In this I have abolished the rheostat, and, instead of varying resistance, I vary the distance of the bobbin from the large conductor.

This instrument is far less cumbrous than the other, and could easily be made smaller still if required.

The large conductor consists of a brass strap along the base, and a return strap at some height above supported by pillars. This brings the terminals close together, and there is a short-circuiting peg and means of breaking the circuit.

The bobbin is mounted on a slide moved by a screw at right angles to the conductor. On each side of the slide along which the bobbin moves is a pointer moving over a fixed scale of ampères on one side and parts of an ohm on the other. In order to avoid any chance of interference from the current in the leads, I supply a double lead consisting of a tube for one conductor and a rod inside it for the other. This arrangement was suggested by Dr. Muirhead. Messrs. Clark, Muirhead, & Co. are the makers of the instrument.

I am sorry that I have not had time to properly calibrate the instrument yet,—indeed, as you see, it is not finished,—but I have put on two rough paper scales showing approximate currents and resistances.

These at any rate serve to show that, while the marks for

current get closer together as the coil recedes from the large conductor, those for resistance get wider apart.

This arises from the fact, that in this instrument we are working by varying the constant as defined for the others, and that this constant appears in the numerator for current and in the denominator for resistance. I have made some calculations on the rate of increase of the increment of current for distance, which I will not trouble you with, but the result I have arrived at is, that if C be the current and D the distance of the magnet from the large conductor, a the height of the large conductor above magnet vertically, and b the current when the magnet is in the centre of the large conductor, then $\frac{d^2 c}{d D^2} = \frac{b^4}{a^2 c^3}$ approximately. That is to say, that by diminishing b, by replacing the simple conductor by several turns of wire, much smaller differences of current could be measured, but of course the range would be reduced. The range of this instrument as it stands is from about 11 ampères to probably 150 ampères, but by an important addition I am going to make I shall be able to measure as low as 1·1 ampère.

This addition is a resistance coil of nine times the resistance of the fine wire coil and cell, which can be plugged in or out.

When it is in the circuit, the current through the fine coil will be one-tenth of what it is at present, and consequently the currents it balances will also be one-tenth of those marked, or the resistances it marks ten times as great.

But I will not detain you any longer with descriptions of instruments, as my object in bringing forward this paper is to arrive at any objections to the principle which I may have overlooked.

The main point is this. Is the constant, as I have described it, subject to variation so long as the instrument is not injured? The first thing to look at is the effect of changes of temperature. I have not tried it with any great differences, but I do not think that in the instrument before you a change of temperature will have much more effect than that of altering the resistance in the balancing circuit, which can be allowed for.

For accurate work, since the constant can be easily taken, it would no doubt be checked occasionally.

CORRECTED READINGS OF ELECTRIC LIGHT CURRENTS.*

Electrometer.	Siemens' Dynamometer.	Converted Obach Galvanometer.	Lt. Cardew's Galvanometer.	
31·44	30·577	30·2	30·17	Using Induction Plate of Electrometer.
29·99	29·013	28·6	28·7	
24·135	23·706	23·62	23·44	
17·447	16·79	17·03	17·03	
17·51	16·79	17·41	17·03	
13·702	13·65	13·52	13·27	
35·35	32·78	32·54	32·51	Using Quadrants of Electrometer.
32·93	32·78	33·1	33·02	
32·8268	32·06	—	32·51	
35·99	35·51	—	35·74	
32·93	32·78	32·94	32·93	
34·35	34·85	34·77	34·56	
38·537	38·65	38·45	38·71	
38·54	38·65	—	38·67	
43·14	43·74	43·45	44·14	
45·60	46·32	45·68	46·51	
51·53	52·89	50·164	53·2	
50·08	50·64	50·25	51·29	
9·488	10·38	9·32	9·421	
6·63	6·82	6·23	6·515	
5·54	—	5·55	5·436	
5·84	—	5·84	5·735	

The PRESIDENT: As time is proceeding rapidly, and we have another paper down for this evening, I think it best to proceed with it, and defer any discussion or remarks members of the audience may wish to make until after Lieut. Bagnold's paper has been read.

* The constant of the dynamometer required correction, on account of the suspending fibre having been renewed.

The following paper was then read:—

THE ORGANISATION AND OPERATIONS OF THE FIELD TELEGRAPH CORPS IN THE TRANSVAAL, 1881, WITH SOME GENERAL REMARKS ON FIELD TELEGRAPHS.

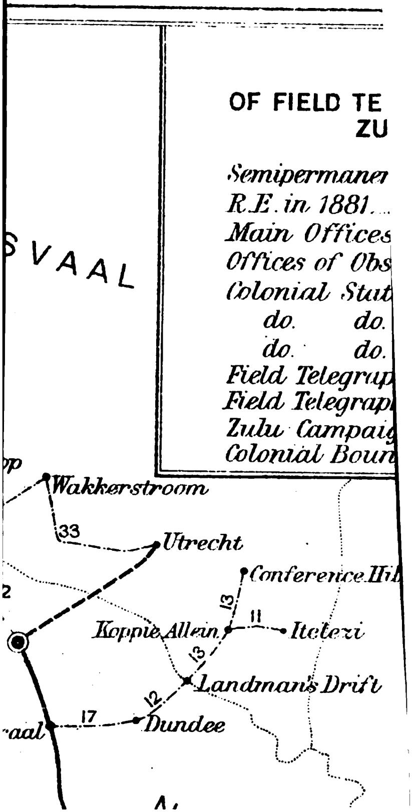
By Lieut. ARTHUR H. BAGNOLD, R.E.

In 1877 the Transvaal was annexed to the British Empire by the now celebrated proclamation of Sir Theo. Shepstone. In the autumn of 1879 the telegraph line from Pietermaritzburg to Newcastle in Natal was extended to Pretoria in the Transvaal, with offices at Standerton and Heidelburg. This line not only proved itself extremely useful during Sir G. Wolseley's expedition against Sekukuni, but it is said to have enabled the authorities to prevent the Boer rising which was so imminent at that time.

The line was constructed with wooden poles cut in the Bush Veldt, in the north of the Transvaal, and with a single No. 6 G.I. wire, supported upon Siemens' iron-hood insulators.

In December, 1880, Her Majesty's forces in the Transvaal, were shut up in their respective garrisons. The Boers had always had an aversion to telegraphic communication with Natal, and consequently, during the advance of the Boer forces towards the Natal frontier, the telegraph line between Heidelburg and Laing's Nek was made an object of their attack. From private information received, I believe that Commandant-General Joubert gave orders that this line was only to be cut to stop communication; but fuel is scarce on the High Veldt, and line wire is very useful for making fencing for cattle kraals. The temptation proved too much for the Boer troops, and eventually the line between Heidelburg and Laing's Nek was completely wrecked,—purposely destroyed off the face of the earth,—the reason being, as I suppose, that it was the major portion of the only public work executed by the British during four years of occupation and government.

On the 8th February, 1881, was fought the battle of Ingogo. On Thursday, the 17th, Sir G. Colley telegraphed to England for a telegraph train, and, being in London on postal telegraph duty,


OF FIELD TE
ZU
Semipermane
R.E. in 1881
Main Offices
Offices of Obs
Colonial Stat
do. do.
do. do.
Field Telegra
Field Telegrap
Zulu Campai
Colonial Boun
VAAL
Wakkerstroom
33
Utrecht
Conference Hil
13
11
Koppie Allein
Itelezi
13
Landman's Drift
12
17
Dundee
aal

I was ordered to set to work at once and get out the lists of the stores that would probably be required. The question now arose at the War Office as to what should be the unit of *personnel* adopted for the expedition. In the Zulu war one-half the C, or Telegraph Troop, R.E., was raised to war strength from the other half, and despatched from Aldershot to the theatre of war. We have only to glance at the map showing the lines laid by that half troop to see what excellent work was then done.

Nothing in this world is, however, perfect; and, acting on the principles involved in the recommendations of a Committee then sitting on military telegraphs, it was quickly decided to send out a section of field telegraphs equipped with 160 miles of material, and to consist of a section of C troop Royal Engineers, made up to war strength by officers, non-commissioned officers, and men from ‑nits of the Royal Engineers employed in the postal telegraph service, viz., the 22nd and 34th companies Royal Engineers.

On Saturday, the 19th, the non-commissioned officers and men were selected, and orders issued for them to be collected at Aldershot; and on the evening of that day I was definitely informed that the command of the section devolved upon myself, with Lieutenant Lindsay as my assistant.

On Sunday, the 20th, I ascertained at the Royal Arsenal, Woolwich, what stores were available, and on Monday, the 21st, the mobilisation may be said to have actually commenced.

At Woolwich Arsenal, the reserve telegraph stores demanded were being packed.

At Aldershot, Lieut. Lindsay, R.E., under the direction of Major Hamilton, was getting ready the headquarters of the section, with its men, horses, waggons, the 12 miles of field cable, and other stores and equipment.

At North Woolwich, the s.s. "France" was being fitted up as a transport for ourselves and other troops.

In London, I was personally occupied in obtaining either from the postal telegraph stores, or by local purchase, such articles as were not available in the Woolwich Arsenal or at Aldershot.

Tuesday and Wednesday gave us all time to complete arrangements, and on Thursday, the 24th, exactly a week after the receipt

of Sir G. Colley's telegram, the section embarked in the s.s. "France," at the Albert Docks, North Woolwich, and the reserve stores were shipped on board the s.s. "Balmoral Castle."

On the following day the "France" sailed.

I will now pass over the period of our voyage, and occupy your attention with a short description of our establishment—that is, of our *personnel* and our *materiel.*

TABLE I.

Establishment.

Ranks.	Mounted.	Dismounted.
Officers	2	...
Serjeants	1	1
Corporals	1	1
2nd Corporals	1	1
Lance-Corporals	...	2
Trumpeters	1	...
Shoeing Smiths	1	...
Wheelers	...	1
Collar-makers	...	1
Sappers	...	20
Drivers	20	...
	27	27
	54	

Qualifications of Non-commissioned Officers and Men.

Manipulators	12 (including 2 Signallers)
Linemen ...	21 (including 8 Signallers and 5 Manipulators)
Artificers ...	6
Drivers ...	13 (including 5 Signallers)
	52

With regard to our *personnel*, Table I. will show you that our strength was 2 officers and 52 non-commissioned officers and men: of these, one officer (myself), had served both in the Field Telegraph Troop at Aldershot and also in the General Post Office Telegraph Department; the other (Lieut. Lindsay), had served three years in the Field Telegraph Troop at Aldershot and Chatham.

Twenty-nine of the non-commissioned officers and men had been trained at Aldershot, and had served in the Field Telegraph

Troop, and 23 had been trained at Chatham, and had served in the General Post Office Telegraph Companies at various places in the southern division. Of these 52 non-commissioned officers and men,

21 were linemen (including 8 signallers and 5 manipulators).
12 „ skilled manipulators (including 2 signallers).
6 „ artificers of sorts.
13 „ drivers (all of whom were more or less trained in linemen's work, and some could signal and manipulate).

We had also with us 11 horses and 18 draught mules, averaging 15½ hands in height.

With regard to our *materiel*, generally speaking we had with us on board the S.S. "France" our camp equipment and baggage, 60 miles of field cable, with 3 waggons specially fitted to carry 12 miles out of the 60; one general service waggon for baggage, etc.; also instruments and batteries for 3 offices, signalling equipment for 2 stations, and a large supply of stationery and forms.

On board the "Balmoral Castle" were shipped 100 miles of semi-permanent overhead equipment, with instruments and batteries for seven offices and construction tools for four working parties.

The whole equipment measured about 120 cubic tons, and the equipment lists comprised 650 different headings.

The following particulars will, I think, give all material details:—

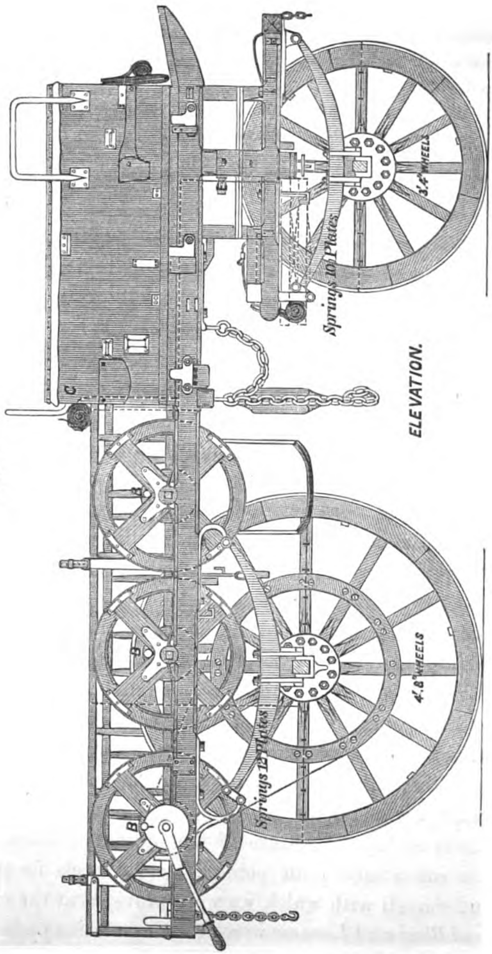
The *accoutrements* were of the ordinary patterns, and do not require description here. Every man, except the trumpeter, carried a short carbine, and the mounted non-commissioned officers and signallers were also provided with cavalry swords.

The *camp equipment* consisted of seven single bell tents and two *tentes d'abri*, also blankets, waterproof sheets, picketing gear, camp kettles, etc.

The *intrenching tools* were of the ordinary patterns, but we afterwards substituted light pointed steel shovels for the heavy spades and shovels with which we were provided at the outset.

The *saddlery and harness* were of the regulation patterns. We had nine riding saddles, and harness for nine pairs of mules so arranged that the mules could be driven either from the saddle or from the box.

FIG. 1.

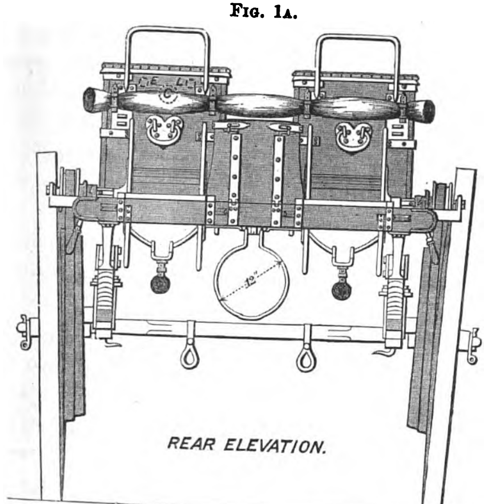

ELEVATION.
Springs 10 Plates
3'.4" WHEELS
4'.8" WHEELS
Springs 12 Plates
B
C

Colonial breast harness in spans of six was afterwards substituted for the harness taken out, the latter having been found unsuitable for mules.

Of *artificers' tools* we had one set of stocks and dies, one of wheelers and carpenters' tools, one of farriers' tools, one of collar-makers' tools, one of shoemakers' tools, also a selection of tailors' implements and materials, and a field forge.

We had also a considerable assortment of loose tools, such as augers, tool baskets, handsaws, screwdrivers, files, gimlets, hammers, grindstones, vices, etc.

FIG. 1A.



It will not be necessary for me to describe our *miscellaneous stores.*

The *carriages,* however, need some little description. The construction of the two cable waggons can be better understood by reference to the drawings (vide Figs. 1 and 1A); and doubtless many of you have seen the pattern exhibited in the Crystal Palace.

The service cable waggon carries six half-miles of cable on drums, also waggon boxes for instruments, batteries, and tools, and is provided with seats for six men.

The cable can be paid out from any one of the drums, if necessary, at a trot, and can be reeled up on the rear drums at a speed of four miles an hour. The fore part of the waggon can be transformed rapidly into a small office. This carriage must be regarded rather as a means of paying out and reeling up cable than as a cable store waggon, for after having provided accommodation for the various tools and instruments required, and seats for the working detachment when their rapid transport is necessary, there remains storage room for from three to five miles of cable only, according to the pattern employed.

The remaining six miles of cable out of the twelve were carried in a general service waggon on drums. Of course, to pay out this cable, it was necessary to shift the drums into a cable waggon, and when thus emptied the waggon was available for general purposes.

Length of wheel base, breadth of track, and elasticity of body are the three qualities required in a waggon for a rough country, and I am sorry to say that none of the service transport waggons possess these qualities to any suitable degree.

On arrival in Natal we obtained some of a far more suitable make, viz., six American-made mule waggons of the South African pattern.

These waggons may be roughly described as constructed exactly like an English timber waggon, except that the perch is fixed instead of being made to slide; while on the chocks, which in a timber waggon carry the timber, is placed a long and elastic trough which carries the load.

Waggons of this pattern and make seem particularly suitable for transporting telegraph material in a rough country where the communications are merely tracks and not worthy of the name of roads.

All our waggons were fitted with poles, and also with powerful screw brakes, so as to be available for use with small mules and horses, or with oxen.

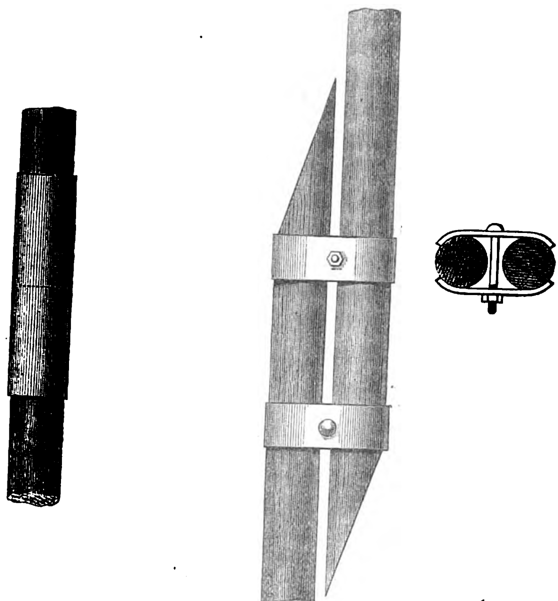
Passing now to the *special telegraphic stores*, the cable was a Hooper's india-rubber core, covered with felt and braided or coach-whipped with hemp. It was of very good quality, and weighed about 270 lbs. per mile. For jointing the half-mile

lengths, ebonite jointers were supplied; also india-rubber tape and solution for repairing wounds and cuts.

Forty-eight miles of cable were sent out in manufacturer's coils wrapped with canvas.

The bare line wire consisted of three strands of No. 18 B.W.G. galvanised iron. This wire was of excellent quality, and was in mile lengths, weighing each about 100 lbs. The poles taken out

FIG. 3.

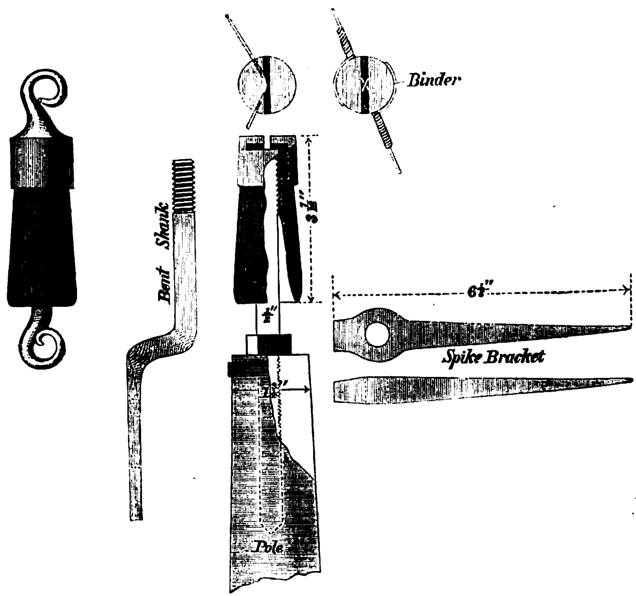


were those which happened to be in stock in the Royal Arsenal; 2,000 of them were 15 feet long, in two pieces and of deal, tapering from 3 inches in diameter to about 1¾ inches. The joint was made by a solid drawn steel socket tube into which the ends were driven, after having been slightly pared with a spokeshave. One thousand of the poles were of similar dimensions, but the joint was a scarf, which according to the original design should have been secured with binding wire. It was, however, found impossible

to carry this out, and I afterwards had 1,000 pairs of iron clips made, and jointed the poles after the fashion of a ship's mast. (*Vide* Fig. 3.) The average weight of one pole with the socket or clips was 12 lbs.

The insulators (*vide* Fig. 4) were single shed and of ebonite, with a half-inch iron stem and brass cap. In the brass cap was an inverted T-shape slot, into which the wire was placed; a quarter turn of insulator, or pole, locked the wire, and prevented it from

FIG. 4.

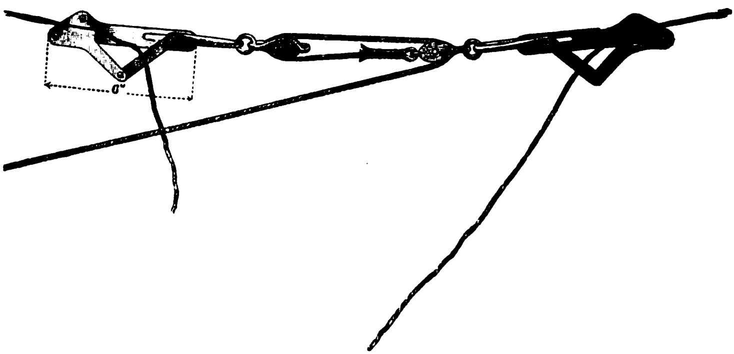


rising out of the slot, into which it could be bound if required. These insulators could be either screwed into the tops of the poles, or could be fastened with a nut into a spike bracket; or the cups could be screwed on to a bent iron bracket capable of being secured to any available woodwork with screws or nails. We also carried some hanging insulators, which could be hooked into the spike brackets, and could be used as shackles when required.

For stays, we had three-strand 16 B.W.G. iron wire; for leads, a good supply of stripped india-rubber core from unserviceable torpedo cable. This was found much handier to work with than gutta percha.

Hand-barrows, with iron drums having horizontal spindles, were supplied from which to pay out the line wire. For straining the wire I had secured several pairs of the light draw-tongs, designed in the Post Office Telegraph Department, for overhouse copper wire. These light steel tongs answered their purpose admirably. Two pairs of such tongs connected with light blocks and tackle (*vide* Fig. 4A) formed the principal implement of our linemen for repairing cuts in the wire.

Fig. 4A.



We also had ratchets for dealing with heavy wire. For each office we had the following stores:—one set of small tools for repairs in a leather hold-all, four ten-cell batteries, one Morse direct writer, one field sounder, one single-current set, three galvanometers, one lightning protector, one chattering bell, and one watch; also a large lock-up, tin-lined chest to contain stores and stationery.

The batteries were of the Leclanché pattern, with ebonite cells and flannel diaphragms: when required to be transported "made up," the outer cells were packed with sawdust.

The Morse direct writers were protected in strong cases, and were so arranged that by means of a switch their connections could

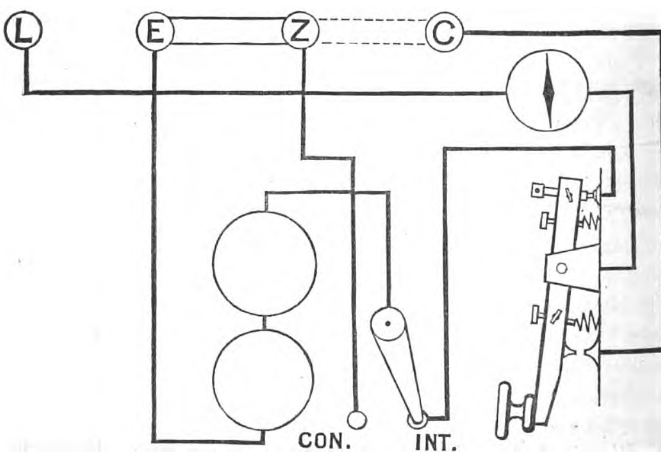
be changed from intermittent current working to continuous or closed current working. (*Vide* Fig. 5).

The field sounders were portable, and were for the use of the linemen.

The single current sets consisted of the ordinary Post Office patterns of single current key, Siemens' relay, and pony sounder, but we had a certain number of double-current keys for emergencies.

We also had six Gower-Bell loud-speaking telephones of the Chatham, or torpedo pattern; but although I once succeeded in

FIG. 5.



speaking between Pretoria and Standerton, a distance of 120 miles, yet, generally speaking, I found that clear articulation was prevented by the presence of earth or aërial currents.

It is to be much regretted that no telegraph stamps were taken out, as we afterwards had considerable difficulty in checking the amounts of collections on private messages.

Having now given you a rough description of our establishment, I must resume my narrative.

Touching at St. Vincent, we were at once saddened and excited by the news of the Majuba disaster, but on arrival at

Simons Bay on the 24th we heard of the armistice. It was naturally a bitter disappointment to us.

A delay of six days then occurred, principally owing to the breakdown of the Maritzburg and Cape Town wire; but on the 30th we were ordered to proceed without delay, as Sir H. Robinson had wisely insisted that the Transvaal telegraph line should be restored before the Royal Commission should pass Newcastle.

On the 2nd April we anchored in the Durban Roads, and the order was given for our section to be landed at once; however, the sea was too heavy on the 3rd and 4th, and we did not get on shore until the evening of the 5th.

The "Balmoral Castle" had arrived before us, and our stores from that ship were being landed simultaneously with those from the "France." A railway siding on the quay was set apart for us, and for four days we were hard at work collecting and checking our stores, fitting up the waggons, packing the whole of the material in railway trucks, and gently exercising our horses and mules, which were naturally somewhat stiff after 42 days on board ship.

The scene on the quay was curious to a degree. Officers, non-commissioned officers, and men with their coats off were all working with a will. A heterogeneous mass of material was being landed, and it behoved every one to look out for himself and for his own. Quaint incidents occurred; everybody good-naturedly endeavoured to "jump" everybody else's property. The scene, however, was no novelty to me; I had experienced the same sort of thing before, when the landing took place on the beach at Larnaca, in Cyprus, in 1878, and on the evening of the 9th we had our waggons and stores all scheduled and packed in a train of 15 goods trucks of the South African or mètre gauge. The 10th was Sunday, and we rested. On Monday morning the train of 15 trucks was split up into three small trains, which were despatched to Pietermaritzburg.

It now became necessary to divide the section into two portions. Leaving Lieut. Lindsay to proceed by march route with the horses, mules, and mounted men, I travelled by train with the stores and dismounted men to Pietermaritzburg.

As I was ordered to start again without awaiting the arrival of

Lieut. Lindsay, my column was furnished with ox transport. The roads were bad, but the grass was still good for the oxen, and my men jogged along cheerily, as a rule singing lustily, so we arrived at Estcourt on the evening of the 16th. One day's rest at this place, and two good marches of 18 miles took us into Ladysmith. Here we found 50 mule waggons awaiting us, so on the 21st we off-loaded and checked all our stores, and on the 22nd we on-loaded the 50 waggons—a good two days' work for the dozen men I had available.

The next day Lieut. Lindsay arrived with the mounted portion, so we got under weigh again that evening, and five easy marches brought us to Newcastle, the advanced base of operations and head-quarters of the division.

On our way up country the Colonists on the road told us they were quite sure that the Boers would oppose the restoration of the telegraph. They christened us, therefore, the *Casus Belli*, an appellation which events proved to be undeserved.

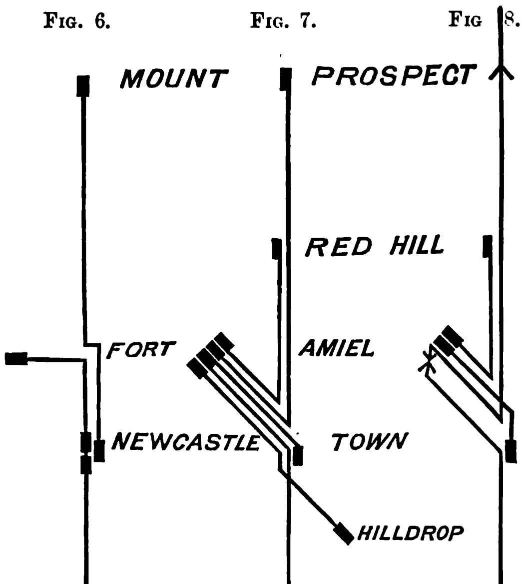
On arrival at Newcastle we found that the idea of restoring the line had been abandoned, owing to some mistaken notion that it would cost £20,000. An excellent chain of heliograph stations had been for some time established to Pretoria by Major A. Wynne, D.A.Q.M.G., and although messages forwarded by this system generally took a whole day to get through, and although the slightest press of work blocked the line, yet people seemed content.

The result was that for nearly three weeks we remained at Newcastle. We found, however, plenty to do. A short line of three miles of cable was laid to Hilldrop Farm, the residence of Sir H. Robinson; another was opened to Red Hill, a central signal station.

The circuits north of Newcastle were transferred by the Colonial authorities to our control, and were subsequently worked by us exclusively; and I cannot let this occasion pass without paying a tribute of thanks to my very good friend Mr. Sivewright, the general manager of the South African telegraphs, for the cordiality with which he and his staff co-operated in all our arrangements, and so furthered success, and ensured the har-

monious working of the whole system. We found, however, that considerable alterations were necessary. Fig. 6 shows how, by the arrangements existing at our arrival, all work passed through the civil office in the town. This was very objectionable. It was almost impossible to prevent important news from being known in the town before it reached the military authorities. The alterations which we made are shown in Fig. 7. This change made better provision for the heavy and increasing traffic between Mount

Fig. 6. Fig. 7. Fig. 8.



Prospect, Fort Amiel, and Pietermaritzburg. Fig. 8 shows the ultimate circuit arrangements at Fort Amiel when the Transvaal line was restored.

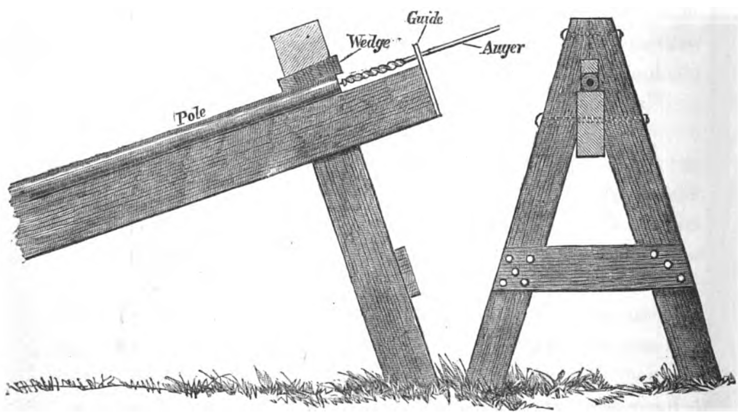
During our stay at Newcastle our establishment was augmented by one civil conductor of transport, six spans of ten mules each, with Hottentot drivers, and four waggons, two of which were American mule waggons, and two were artillery general service waggons, which I had specially fitted to carry 4½ miles each of

cable. Thus my 12 miles of cable carried ready for use were increased to 21.

On the 13th of May I received orders to estimate for the temporary restoration of the Pretoria line, and my estimate of £2,000 (which afterwards proved ample) was no sooner received than the order was given for us to proceed at once with the work.

The first thing to do was to fit the poles together and to bore them for the insulators, for which latter operation I had to make three boring trestles (as shown in Fig. 10). I then had four ox waggons loaded with 113 iron poles from Utrecht line. This line, I should here say, had been dismantled, and its iron poles had been

Fig. 10.



stored at Mount Prospect. The waggons were started up the road to Heidelburg in charge of a Sapper, who dropped an iron pole at each mile. Fourteen ox waggons were soon loaded with our 100 miles of overhead equipment, and on the 21st May we started from Newcastle with these waggons, with our eight mule waggons, and 12 Kaffir workmen to assist in digging holes. On the 23rd we arrived at Coldstream, at which place, on the morning of Tuesday, the 24th, we commenced to construct the semi-permanent line.

Our method of procedure was as follows:—The general direction having been selected, a mounted man carrying a flag and in charge of one waggon was sent on in front; this man took up the align-

ment as directed by signal, and in the first instance acted as a point to work on. He afterwards employed his waggon to drag the iron poles, dropped on the road, on to the alignment. Of course, when half a mile or so of line had been erected, the direction was continued by lining the diggers on the poles already erected.

The diggers (12 in number) worked in pairs; one Kaffir with a pick, the other with a shovel, which was marked to indicate the required depth of the hole, viz., about 18 inches.

The diggers were in charge of two dismounted men, one of whom was held responsible that the alignment was correctly kept.

A mule waggon followed, from which two or three men paid out the wire. A great deal of difficulty was experienced in this, as the coils had been much knocked out of shape in transport, and would not pay out freely.

Next came a waggon with poles and insulators. One man screwed in the insulators, which were kept in a box suspended at the back of the waggon, and placed the poles on the ground at right angles to the alignment, with the insulators just over the holes. This man also deposited stays and stay pegs at every eighth pole, and attached the brackets and insulators to the iron poles.

Two men then followed, straining up the wire; each of these men carried a pair of light draw-tongs attached to their waist-belts. One man would attach his draw-tongs to the wire at a point not less than one and a half bays in front of the building party, and, leaning back, would strain the wire hand-tight. The other man would double on for a bay or two, and when he had got the strain he would shout or blow a whistle, when the first man would let go and double on ahead, the strain being thus continuously kept up.

The building party, consisting of from three to five men, placed the wire in the insulators (binding it in at every alternate pole), erected the poles, filled in the holes, and rammed them.

This party also fixed rocking stays at every eighth pole, and fore and aft stays at every sixteenth. About 25 wooden poles were used to the mile. At every mile we erected an iron pole of Clark & Muirhead's pattern, weighing about 160 lbs. At these poles the wire was generally shackled off, and one of these poles

was always used when changing direction. When crossing a river or ravine, and if an iron pole was not then available, two of the ordinary poles were lashed together, and well stayed all round.

Close in rear of the building party followed a dismounted non-commissioned officer, who was responsible that the work was properly done, and that no tools were left lying about the Veldt.

Lieut. Lindsay took general charge of the whole working party, whilst I was engaged in selecting the alignment, choosing the camping ground, or looking after the main convoy of waggons, which was directly in charge of a mounted non-commissioned officer. The communication was kept up between myself, the working party, and the convoy by means of signalling, each officer carrying a small flag for that purpose. Every soldier worked with his carbine slung, and every Kaffir had his bundle of assegais and knobkerries beside him. I may here mention that it would have been next to impossible for the soldiers to have worked with the long rifle.

Working in the manner described, we completed four miles the first day, and camped at Van der Skyft's farm, close by which place we were considerably annoyed by a whole span of ten mules getting bogged in the "vlei," a colonial term for a slough of despond.

The second day we completed five and three quarter miles in the forenoon, and camped at Sand Spruit, where the whole of our camp equipment was burned by a "grass fire;" however, our waggons and waggon cloths furnished ample shelter for the night; and the third day, meeting rocky ground, we only managed six and a quarter miles.

On the fourth day we constructed nine miles, but had to go on seven miles to find water. On the fifth day we divided into two parties; I went back to carry on the wire from Spitz Kop, whilst Lieut. Lindsay worked on towards Van der Berg's farm. Collectively the two parties completed 15 miles that day; the last mile of my bit being completed in the dark. Unfortunately, however, the two parties missed one another in the evening, and as I had all the camp equipment and the next day's rations with me, Lindsay and party had to bivouack on the open Veldt, at an

altitude of 6,000 feet. The test was rather a severe one, as it froze hard during the night; but Lindsay's usual cheeriness of disposition and characteristic energy, which never forsook him, stood him and his party in good stead, and, when we met again on the following day at Kat-Bush Spruit, he could point with no little satisfaction to six miles of line well completed, as his early morning's work. On the seventh day, paying out nine miles of cable, we got into Standerton early, where we at once established an office in the Court House. In crossing the Vaal River at Standerton, the field cable was tied to a No. 6 wire and slung across from bank to bank.

At Standerton we established our headquarters, and on the 2nd June Lieut. Lindsay and party marched to Waterfall River, a distance of 21 miles; on the 3rd he commenced constructing the line towards Heidelburg, and the same day I marched to Waterfall with a small party; and on the 4th, 5th, and 6th built the line back from Waterfall to Standerton.

On Tuesday, the 7th, Lindsay got into Heidelburg, and as the old line between that place and Pretoria proved to be in fair working order, and as a clerk of the old staff was on the look-out for signals, we found ourselves through at last to all stations, and very pleased we were at the discovery.

Thus 100 miles of field line had been constructed in 13 working days. Five principal offices had been established, viz., at Fort Amiel, Mount Prospect, Standerton, Heidelburg, and Pretoria, and each office was provided with a single current set, and afterwards testing stations or linemen's offices, equipped with field-sounders, were established at Coldstream, Paardekop, Waterfall, and Cason's.

On the 15th of June the chain of heliograph stations was removed, as there was no further necessity for communication by visual signalling.

Table II. shows the ultimate disposition of manipulators and linemen for working and maintaining the line. All sections were patrolled by mounted or dismounted linemen once every two days. During the winter season, comprising June, July, and part of August, the weather was dry and fine, and the grass being dead,

but few oxen were on the High Veldt. The Boers also did not give us much trouble: they said "dat die telegraph vaas goot," as they were expecting great things from the Royal Commission, which gave us as much work as the line would carry.

TABLE II.

Ultimate Distribution of Staff and Transport.

PLACES.	"Cape" Carts.	Waggons with spans of Mules.	Riding Horses.	Non-commissioned Officers and Men.	
				Clerks.	Linemen.
Pretoria	...	1	1	2	2
Heidelburg...	...	...	...	2	1
Cason's	...	...	...	1	...
Waterfall	...	...	1	1	1
Standerton...	1	4	7	2	27
Paardekop	...	1	4	1	3
Coldstream...	...	...	1	1	1
Mount Prospect ...	...	...	1	2	1
Newcastle	...	...	1	3	1
	1	6	16	15	37
				52	

Note 1.—Working parties included as at Standerton.

Note 2.—In this case the Staff was concentrated as far as possible at Standerton (Headquarters of the Field Telegraph), in order that, in case of a sudden outbreak of hostilities, as few men as possible might have been cut off.

After the 8th August, however, when the convention was published, and during the three spring months which the new State had to consider and ratify the proceedings of its Triumvirate, the maintenance of the line was a matter of the greatest difficulty. The Boers annoyed us very much, by constantly cutting the wire and carrying off small portions as trophies.

Only such faults as actually stopped the working were recorded, and of these faults (65 in number) 17 were caused by malice, 14 by storms of wind or snow, 11 were caused by lightning, 10 by cattle (herds of which had been driven down from the Bush Veldt to feed on the young grass), 8 I have classed as due to pure

accident, 3 to sheer neglect, 1 to a grass fire, and 1 to decay of material.

Except during the sitting of the Commission, we did not work after eight p.m., and, deducting the night time, the average duration of faults was seven hours—that is to say, that during the 175 days and nights the line was open for traffic, there were 65 days in which the line was broken down for seven hours each day.

Among the faults due to storms and lightning are included interruptions by strong earth currents, which invariably accompanied such storms. These earth currents were often of such strength that the galvanometers would be deflected for many minutes to the full extent of the scale. On one occasion, during the terrible snow-storm of the 26th and 27th August, I endeavoured to put the Fort Amiel wire at Standerton through a galvanometer to earth. The end of the wire felt quite hot, a phenomenon also noticed by the clerk in charge of the office. We had hardly replaced the wires on the protector when a discharge took place which shook the whole instrument set. Flashes of lightning would cut our line wire and shiver the poles and insulators into atoms. On one occasion whilst a Sapper was re-erecting a fallen pole, he was knocked flat, and the pole was shivered in his hands. I have here a piece of No. 6 wire, which you will see has been drawn out like sealing-wax.

Had it not been that we had really excellent manipulators, whose training in the General Post Office had accustomed them to work off heavy batches of messages at a rate of from 25 to 40 words a minute, our task would never have been accomplished, for it is only highly skilled clerks that can be safely entrusted with the long strings of cipher groups and figures employed during a period of military or political agitation.

During the time our line was open, 1,115,158 words were received at, and 1,117,648 words were signalled from the military offices between Newcastle and Pretoria. The total amount of collections on private and press messages amounted to £1,170 7s. 4d.; one press message alone numbered over 5,000 words.

The maintenance of the line could not be carried out by the linemen alone, who had quite enough to do to remove faults and

patrol the line: working parties of from two to four soldiers, and from two to four natives with one waggon, were constantly employed resetting the poles and keeping things straight. Gradually the number of iron poles on the Coldstream and Standerton section was doubled, and the piece of cable near Standerton was replaced by an overhead line for fear of grass fires, which burned the cable, but which never did any damage to the poles.

A translator was extemporised at Fort Amiel, and Fig. 11 shows the connections of this instrument set. This arrangement worked capitally, and saved the Fort Amiel clerks much manual labour. By this arrangement, also, *direct* communication was maintained between Pretoria and Cape Town (a distance of 1,400 miles), through the translating stations at Fort Amiel, Pietermaritzburg, Umtata, and Fort Beaufort.

It was thus that Major Le Mesurier, R.E., was enabled to prove his observations for the longitude of Pretoria and other places, the exact geographical position of which had never previously been ascertained.

Shortly after I arrived at Standerton I purchased at my own expense an open two-wheeled Cape cart, and I found this cart, with two, four, or six mules, most useful, not only for inspecting the line, but for the repair of faults. To show how it facilitated my movements, I may say that one Sunday our morning tests showed a disconnection between Standerton and Waterfall; at 9 a.m. I "inspanned" the trap, started off with my bâtman, found and repaired the fault at a distance of ten miles, and, having erected four poles and several bays of wire, was home again before noon.

On the convention being ratified we received instructions to hand over the whole line to the Boer Government. This we did, though no telegraphic communication has passed down the line since the 22nd of November, when the section, the last remnant of military occupation, crossed the Vaal River, and in two days' march reached Natal, homeward bound.

I had for two years watched the excellent results of British rule, freshly planted in a portion of the Ottoman Empire, and it was with a heavy sigh that, on reaching the Coldstream, I furled the Union Jack on the last military waggon that crossed the

soldiers, and
tly employed
radually the
rton section
vas replaced
d the cable,

ig. 11 shows
ent worked
al labour.
naintained
0 miles),
aritzburg,

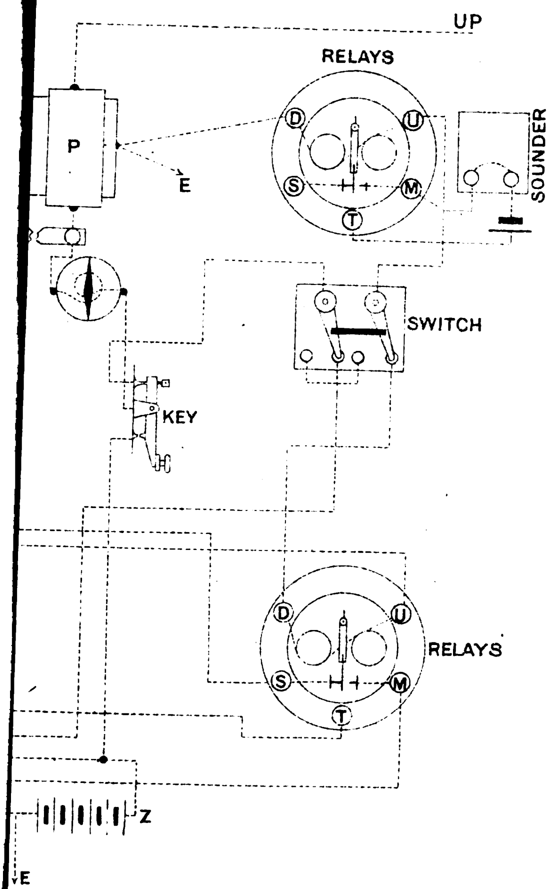
to prove
aces, the
sly been

my own
rt, with
ing the
ed my
showed
a.m. I
d and
d four

ons to
e did,
e line
onant
days'

ritish
nd it
furled
d the

11.
TING SET.



boundary between Natal and the new Transvaal State, the like of which state exists not in this world, and let us hope not in the next.

Although the experiences which I have just related to you were not those of active service, yet our operations in South Africa may, I think, be said to have formed a very crucial experiment in practical military telegraphy; and as I have been more or less connected with the military telegraph service since 1874, I trust that you will pardon me if I now make some general remarks on field telegraphy.

Field telegraphs have been divided by common assent into advanced, or flying telegraphs; semi-permanent, or intermediate telegraphs; and reserve, or permanent telegraphs. This division seem logical enough for purposes of war in and between civilised countries, and is therefore maintained by Continental armies in their organisations, both as regards *personnel* and *materiel.* The conditions of active service in the British Imperial Army are, however, generally quite different to those under which our Continental neighbours make war; and as we are liable for service in distant colonies, and against savage as well as civilised people, it behoves us to be ready for any and every emergency. We must therefore have in store reserves of all three classes of telegraph equipment; and for the same reason it has been decided that our war unit of *personnel* shall be of a character readily adaptable and applicable to all circumstances of war.

Much discussion has taken place on the fitness of various descriptions of material for field service.

Visual signalling by heliograph to a certain extent takes the place of an advanced telegraph in a country where the climate is good and the atmosphere clear, but a much better class of army signaller must be employed than is employed at present if any real work is to be got out of a chain of signal stations. Moreover, I do not think visual signalling will ever compete with an advanced telegraph until the electric light is employed at night. Again, in dull and cloudy climates signalling is of no use, and field cable or a very light overhead equipment is the only substitute. A ground

line is also, I fancy, the only means by which rapid communication can be established in a rocky country where poles can only be planted with great difficulty. The use of a ground cable, however, is very risky in an open grass country, as grass fires burn the cable very rapidly. The only practicable method of burying a cable in the field is to use a plough.

A semi-permanent overhead equipment seems to me to be that which will be mostly required in our Colonial wars, and of this class of material a large stock should be always kept in hand.

From my experience in the Transvaal, I conclude that a section of field telegraphs, fifty-four strong, could always work and maintain 100 miles of such material which should not weigh more than 600 pounds per mile.

The 100 miles of the original line which we restored, maintained, and worked, in addition to the 100 miles of field line which we had constructed, gave us a great deal of trouble. A great many faults occurred on this piece of restored permanent line, and most of these faults were of much longer duration than those that occurred on the field line.

For pack transport, poles should be jointed, though this is by no means absolutely necessary. Bamboos form the best telegraph poles for military purposes, and for an advanced overhead equipment, with wheeled transport, I do not think that single lengths of light bamboos can be surpassed. There is, however, some difficulty in making a satisfactory joint in a bamboo, whereas fir poles of almost any size can be jointed with the weldless tubular steel socket introduced by Colonel Webber, R.E., our gallant President.

One great advantage is gained by making fir poles in two pieces, and that is, that straightness of grain can be easily obtained without difficulty and without incurring extra expense.

Every dry climate has either a wet season, or else it has very heavy dews; it therefore follows that insulators must be employed in every military equipment, and the pattern of insulator adopted in our service leaves little to be desired.

For line wire I submit that a soft, annealed, galvanised steel wire possesses to the greatest possible degree the requisites of lightness, pliability, and tenacity.

Wire for advanced equipment should not weigh more than 60 pounds per mile, but I think that wire for semi-permanent equipment should weigh about 150 pounds per mile.

Every important office should be equipped with relay and local sounder. I do not think that reading by sound from a local sounder can be surpassed for rapidity or accuracy when good manipulators are available. The human ear seems to me to be so delicate that it can detect signals when an ordinary inker will not print. Direct sounders are not, however, suitable for important offices, owing to the difficulty of adjustment to the current, which must always be varying on a field line.

Inkers must be provided in reserve in case of sickness among the skilled staff, in which case inferior manipulators would probably have to be employed.

For unimportant offices, such as those I established at Cason's, Waterfall, etc., a direct sounder with a light armature will answer well.

I consider that the best way of working a long single wire, which is liable to be cut at any point, is by having translating stations at every 50 miles; the whole circuit is thus divided up into independent sections, each of which is unaffected by the faults on any other section, whilst direct through communication can be obtained.

In such translating sets each side must be complete in itself; there must be no recording at the translating stations by means of the outgoing current, and I submit Fig. 11 as the most simple system of translation which will fulfil all necessary requirements.

The Leclanché system answers well for main batteries; but the Silvertown Company must manufacture better ebonite cells before they can be said to have produced a really portable Leclanché battery.

In the dry winter atmosphere of the Transvaal, I found that Leclanché's failed as locals, and Daniell batteries had to be substituted. It remains for some one to design a really portable form of local Daniell battery.

On active service all linemen should either be mounted, or they should be provided with two-wheeled spring carts. Horses for linemen's work should be of the cobby, weight-carrying description.

I do not know of any form of tent in our service which is really adapted for use as a telegraph office. The Indian "pâl" tent is very fairly suited for the purpose, but personally I should always prefer, when possible, to make use of existing buildings, or to run up temporary offices, such as we constructed at Mount Prospect and Standerton, with sod or mud walls and galvanised sheet-iron roofs.

For earths, I know of nothing better than the earth-pipe at present used in our service, and I think that something on the same principle might be usefully adopted in permanent telegraph systems.

I had intended to have made a few remarks and suggestions to-night as to the organisation of our Field Telegraph Corps in time of peace, but, having regard to the fact that the whole subject is now under the consideration of the authorities, I think it would hardly be expedient for me to touch upon the point in a private paper.

I have, however, a few remarks to make with regard to our work in war time, which I think can well be stated here.

In making war in a civilised country, the function of the Field Telegraph Corps would be to repair existing lines, and to connect rapidly the various headquarters with those lines. In most instances, therefore, units for such a war would have to be equipped as advanced units.

In a Colonial war, however, few existing lines would be available, and the Field Telegraph Corps would therefore be used to form new lines of telegraphic communication, and for this purpose the units would have to be equipped with semi-permanent material.

At the end of a campaign these semi-permanent lines may have to be abandoned, as not worth the cost of transport; on the other hand, they may have to be strengthened and rendered more permanent.

This might be effected in one of two ways: either the supports might be replaced by heavy poles of wood or iron, or the lighter military poles might be attached to stout spurs or raised up on iron standards. Let us hope, gentlemen, that in our next Colonial war the military telegraph lines may, instead of being abandoned, as

seems now to be the custom, be strengthened and rendered permanent, and thus become fresh monuments of our national energy in spreading civilisation in and even beyond the remotest regions under our control.

The PRESIDENT: The hour is so late, gentlemen, that I imagine there are not many who wish to listen to what may be said after the interesting papers which we have just heard. It is invidious to criticise, and I should be the last in my place to do so, but I should like to make a remark on each of the two papers.

In regard to the very interesting one of Lieut. Cardew's, I fear the discussion on it will be curtailed by the absence of diagrams. Our members and associates who read papers here should not forget, that without illustration by diagrams there is great difficulty for the audience to understand a paper clearly, and to discuss it afterwards.

As regards Lieut. Bagnold's paper, I should have liked his admirable diagrams to have been accompanied by a glossary of the terms which he used. The Colonial term "jump," and the terms "inspan" and "outspan," have not yet been put into the technical dictionary of the Society of Telegraph Engineers. With this exception, Lieut. Bagnold's paper was one of the most interesting of the kind we have heard within these walls.

Mr. W. H. Preece, who much wished to be here to-night, asked me to read a portion of a letter addressed to him by our friend Mr. J. Sivewright, to whom Lieut. Bagnold alluded in his paper. Mr. Sivewright says, with reference to the work done by the force under Lieut. Bagnold, that "in face of difficulties which people at home could hardly credit, they maintained temporary communication between Laing's Nek and Heidelburg."

I would add my own testimony to the nature of the country. Being free from fences, it is, in some respects, an extremely easy country in which to construct a telegraph line. In January, 1880, I rode side by side with the line from Pretoria to Pietermaritzburg, 370 miles, and the difficulties and facilities for construction were very evident. The difficulties were evidenced by the fact that the original line, which was ordered by a telegram from Sir Michael Hicks Beach to Sir Bartle Frere in August, 1878, cost

over £80,000. That is sufficient evidence of the difficulties of construction. The facilities arise out of the nature of the country, which permits of the line being put up in a straight line for miles. The cost of transport of the materials in time of war was one of the greatest difficulties; and the whole of the labour had to be imported from Kaffraria, a distance of several hundred miles, which greatly enhanced the cost. The troubles of maintenance of the original line mentioned by Lieut. Bagnold were, I think, partly due to one circumstance which I noticed when inspecting it. The wire was suspended on hook insulators, and fixed in position by wedges in wedge insulators, at intervals varying between 7 and 14 spans, according to the plan devised by one of our well-known firms. In one place near Coldstream, where the wire had been cut or broken, I found 13 spans lying on the ground, a length of No. 6 wire almost impossible for one lineman to draw up and secure.

In regard to translation, there is no doubt that translation is, in common with a local station circuit, a most admirable assistant in the working of a defective line; but whether translation can be used on military lines every 50 miles I think is very doubtful, owing to the weight of the apparatus that would have to be carried.

I would only add, as regards Lieut. Bagnold's own work, that in a despatch written by Sir Evelyn Wood, in connection with the operations on hand during the time of military operations in the Transvaal, he mentions the admirable work done by Lieut. Bagnold and the officers and men under his command, in terms which any body of men might well be proud of.

Professor AYRTON, F.R.S.: Like the others present, I have been much interested in the communication which Lieutenant Cardew has been so kind as to give us, and my interest has been the greater because Lieutenant Cardew has been travelling along some of the lines traversed by Professor Perry and myself in the construction of simple instruments for measuring strong currents and small resistances. When attempting in 1879 to employ the two-coil method for measuring currents, which Lieutenant Cardew has more recently adopted, we came to the following difficulty,

which I fear Lieutenant Cardew will find it not easy to overcome, and it is this: as long as you trust to the weak earth's field to control your suspended needle, it is easy enough to have many turns of the fine wire coil close to your suspended magnet, and one or two convolutions of the thick coil farther away; but if, to make the instrument dead-beat, a powerful permanent magnetic field be attached to the instrument, then it requires several convolutions of the thick wire traversed by the strong current to be put close to the suspended magnet to produce a deflection, and in that case you cannot approach the fine wire near enough to the magnet for the weak current to equalise the action of the stronger. We therefore abandoned this method, which has been followed by Lieutenant Cardew, and instead used in our ammeter, as the members are aware, the very same convolutions of wire for the thick coil and for the thin.

Lieutenant Cardew's galvanometer for measuring currents is obviously intended rather as a laboratory instrument than as a portable one to be used anywhere, since a new well-made Daniell's element, necessary to be used with it each time a measurement is made, cannot be found at an electric light installation, and to carry a large cell, such as is on the table, about with one, is troublesome.

His instrument for measuring small resistances has the same object as the ohmmeter of Professor Perry and myself, but fulfils its object in a different way. He makes the difference between E and C equal to nought where E is the electro-motive force between the two ends of that portion of the circuit of which it is desired to measure the resistance, and C the current in the main circuit, while we measure the actual ratio of E to C, or the resistance, directly. With this differential galvanometer of his, a balance method is alone possible, for otherwise the zero of his instrument would vary with the strength of the current flowing in the main circuit, and the calibration of such an instrument would be impossible.

It appears to me that zero instruments, although they possess considerable sensibility, are unsuitable for quick, rough work, since quick changes cannot be measured by them, and I therefore prefer

dead-beat instruments like our own, in which the pointer points to the answer at once, without the necessity of adjusting a screw or otherwise obtaining balance each time a measurement is made.

But I have no doubt that in the laboratory Lieutenant Cardew will obtain most valuable results with his instruments, as they certainly show that he possesses both originality and ingenuity in designing measuring instruments of this class.

Lieut. P. CARDEW: In my instruments I have hitherto relied chiefly upon the magnetism of the earth, because in the laboratory, as Professor Ayrton has remarked, we can do so by taking precautions; but now assisting magnets will be seen to be fixed in each of the instruments for the purpose of making the instrument more of a dead-beat character, and it is easy to take an average of the swing of the needle to either side of zero. By the sliding arrangement I described, the operation is much more rapid than the usual method, and the calibration can be done by hand easily without the aid of the screw. I should mention that the box containing the sliding instrument also contains a compartment for the reception of the standard Daniell cell, which will be of a pattern that requires very little attention to keep in working order.

Lieut. A. H. BAGNOLD, R.E.: Faults on the existing portions of the original line were not caused either by the use or by the abuse of Siemens' iron-hooded insulators, which seemed to me to have answered their purpose very well. Special "straining" or "wedge" insulators were employed at about every eighth pole. The faults I referred to were caused by the rotten condition of the poles, which were of "Buckan-wood," a class of timber very unsuitable for telegraph construction. This wood has a large proportion of "sap," which decays rapidly, becoming very inflammable, and its "heart" is very brittle.

In regard to translation, a set of instruments, as shown in Fig. 11, weighs 25 lbs., whereas our service pattern Morse direct writer weighs 28 lbs. I did not employ the word "outspan."

The PRESIDENT: I imagine that, as the clock has struck ten, it is far too late to go through the usual form of asking the members present to propose and second a vote of thanks to the readers of these interesting papers, and I only ask to be supported

by your acclamations in returning thanks to them to-night on behalf of this meeting. (Accorded.)

I should now mention that this is the last evening of our spring session, and that it is very necessary that members should recall to mind that there are some twenty proposals to be voted for, and I hope that all present will record their votes.

A ballot then took place, at which the following were elected:—

As Foreign Members:

Monsieur Armengaud (jeune). | Cavalier G. N. Moerath.
J. Chester Wilson.

As Member:

Colonel J. D. Shakespear.

As Associates:

Lieut. F. G. Bond, R.E.	Frank Howard.
Captain H. V. Hart Davis, R.E.	J. H. A. MacDonald, Q.C.
W. H. Findlay, B.A., F.R.A.S.	J. Roper Penning.
John Gell.	John Tasker.
Francis G. Gostling.	William Howard Tasker.
Henry Charles Ernest Hill.	Samuel Trott.

As Students:

Paul Dimier. | Charles Cecil Erichsen.
Francis Elliott Stuart.

The meeting then adjourned until the 9th November, 1882.

RECEPTION OF MEMBERS BY THE PRESIDENT, AT CHATHAM, ON THE 11TH JULY, 1882.

The President's Reception was, by permission of Major-General Sir Evelyn Wood, V.C., G.C.M.G., R.E., commanding the Chatham District, and of the Commandant of the School of Military Engineering, held at the Brompton Barracks, including luncheon at the Royal Engineers' Mess, followed by an inspection of the Schools.

Invitations exceeding 1,000 in number had been issued by Lieutenant-Colonel Webber to members and others, nearly one-half of whom availed themselves of the opportunity thus afforded them of visiting all that is of most interest in this important military establishment.

Special trains from the London termini of the London, Chatham, and Dover Railway were provided for the accommodation of the guests, and the following admirable arrangements were made to enable so large a body of visitors to witness the different operations without confusion:—

Printed notice distributed to visitors in the trains.

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

THE PRESIDENT'S RECEPTION AT CHATHAM,

JULY 11TH, 1882.

The whole body of visitors will, for the purpose of inspecting the Schools, etc., be divided into groups of about 25, each group being indicated by having programmes of one colour and bearing the same letter in the corner; visitors desiring to keep together are therefore recommended to present their invitation cards at the same time, so as to receive in exchange programmes of the same letter and colour.

Officers of the Royal Engineers, whose respective names will be found on the programmes, have kindly undertaken to conduct the several groups.

To each group will be allotted a flag-bearer, who will carry a flag of the same colour and marked with a similar letter as the programmes.

Immediately after the reception, each visitor is requested to attach himself to the group indicated by the colour and letter of his programme.

Visitors comprising each group are requested to proceed to, and leave the luncheon at the same time.

The Brompton Barracks are situated a little over twenty minutes' walk from the L. C. & D. Railway Company's station at Chatham, but visitors who wish to drive will find conveyances at the station; each driver with a placard has agreed to carry visitors to the barracks at 6d. each, and bring them back at a similar charge.

On arrival enter at the Memorial Arch, and on departure leave by the South Gate.

Printed instructions issued to the leaders of groups.

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

RECEPTION BY THE PRESIDENT,

AT THE

SCHOOL OF MILITARY ENGINEERING, CHATHAM,

11TH JULY, 1882.

INSTRUCTIONS TO GROUP LEADERS.

The following officers have kindly undertaken each to conduct a group of guests holding programme cards of the same colour, and letters as printed against each name, namely:

Lieut.-Col. E. C. Sim	A	Major Slacke	K
" Durnford	B	Major Salmond	L
" Seddon	C	Lieut.-Col. Helsham Jones	M
Major H. Tovey	D	" Maitland	N
Captain J. du T. Bogle	E	" Malcolm	O
Major Bond	F	" Festing	P
Lieut. Irvine	G	Lieut. Mills	R
Major Alves	H	Captain Garwood	S
Lieut. Ross of Bladensburg	I		

Each officer will be provided with a small hand flag, coloured and lettered to correspond with the cards, so that each group will know its leader.

The reception (weather permitting) will take place just within the Crimean Memorial Arch.

A programme card will be handed to each guest as he passes through the

arch, and after his reception he will pass on and be received by the group leader of his colour and letter.

INSTRUCTIONS FOR GROUP LEADERS "A" TO "H," INCLUSIVE.

As each group is completed it will be conducted at once to luncheon. It is desirable that these luncheons shall be finished by 1.30 p.m., so as to give 30 minutes to relay the tables.

1 p.m.—Leaders will conduct their groups to luncheon.

1.40 p.m.—Lecture by Major Armstrong in the Lecture Theatre.

2.15 p.m.—Tour of visits as per list, and in the order furnished to each leader.

INSTRUCTIONS TO GROUP LEADERS "I" TO "P."

As each group is completed it will be conducted at once to the Lecture Theatre.

1 p.m.—Lecture by Major Armstrong in the Lecture Theatre.

2 p.m.—Leaders will conduct their groups to luncheon.

2.30 p.m.—Tour of visits as per list, and in the order furnished to each leader.

INSTRUCTIONS TO ALL GROUP LEADERS.

If the time allotted is exhausted, leaders are requested to proceed from the Institute to the field works, and *vice versa*, at the time specified, omitting the remaining visits.

If leaders find a room at the Institute already occupied by a group, they are requested to pass to the next, and not return to it unless time permits.

4 p.m.—Assemble at St. Mary's Casement to view the explosion of submarine mines.

5 p.m.—Leaders will conduct their groups back to the reception place, where (weather permitting) tea will be served and the band will perform. Guests should leave so as to reach the London, Chatham, and Dover Station at

Copy of coloured programme cards and programmes issued to each guest on presentation of his card of invitation.

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

RECEPTION BY THE PRESIDENT,

AT THE

SCHOOL OF MILITARY ENGINEERING, CHATHAM,

11TH JULY 1882.

______________________ has kindly undertaken to conduct the guests holding cards of this colour and letter, who are requested to keep together after the reception, and follow the flag of their conductor, which corresponds with the colour and letter of this card.

PROGRAMME.

1 p.m.—Luncheon at Mess, for holders of cards "A" to "H."

1 p.m.—Lecture on Submarine Mining by Major Armstrong, R.E., in the Lecture Theatre, for holders of cards "I" to "P."

1.40 p.m.—Lecture on Submarine Mining by Major Armstrong, R.E., for holders of cards "A" to "H."

2 p.m.—Luncheon at Mess, for holders of cards "I" to "P."

2.15 p.m.—Visits to the R.E. Institute, including the Schools of Construction, Surveying, Photography, Printing, Chemistry, Lithography, and Electricity; Model Room; Fieldwork Instruction; Steam Sappers in use; R.E. Park and Workshops; Instructions in Modelling; Types of Field Redoubts and Batteries; Various kinds of Intrenching Tools; Cavalry Pioneer Equipment; Various kinds of Gabions; Field Bridges, and use of Spars; Demolition of a Railway; Firing Mines of Attack on land, and forming Lodgment; Siege Operations by the Royal Artillery.

4 p.m.—Demolition of Stockade; Firing Mines in the Medway.

4.50 p.m.—Procession of Steam Sappers outside the Archway.

5 p.m.—Afternoon Tea, during the performance of a selection by the R.E. Band.

Twenty-five minutes should be allowed to walk to the London, Chatham, and Dover Railway Station.

These cards had on the reverse side a plan of the barracks and other military establishments, the Chatham Lines, etc.

Copy of detailed programme.

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

RECEPTION BY THE PRESIDENT,

AT THE

SCHOOL OF MILITARY ENGINEERING, CHATHAM,

JULY 11TH, 1882.

PROGRAMME.

ROYAL ENGINEERS INSTITUTE.

LIBRARY.

This is one of the principal of the 30 professional libraries maintained by the officers of the corps. There are about 9,000 volumes.

PHOTOGRAPH SCHOOL.

Plans, maps, and drawings are copied, and photographs of all sorts taken for record and experimental purposes. There is a large copying and enlarging camera for plates up to 3′ 0″ × 2′ 6″.

MUSEUMS.

This is in its infancy, and is supplementary to the collection in the model room. The museum of building materials and appliances is for the use of the Construction School.

CONSTRUCTION SCHOOL.

Officers go through a six months' course of engineering construction. Military foremen of works are instructed in building construction. Pioneer classes are taught the building trades.

PRINTING SCHOOL.

Printing is taught, and the daily orders are printed in the service waggon. Forms, papers, and lectures, etc., in fact the printing required for the School of Military Engineering generally, is done here.

SURVEY SCHOOL.

Technical surveying and military topography are taught to Royal Engineer officers, non-commissioned officers, and sappers; military topography to classes of officers of other arms of the service. The technical surveying course consists of geodesy, astronomy, meteorology, trigonometrical surveying, road surveying, and defilade. The military topography course consists of military surveying, military sketching, and elementary reconnaissance. Geology is also taught in this school.

LITHOGRAPH SCHOOL.

Lithography, zincography, heliotype, etc., are taught. The "heliotype" process is used for the reproduction of photographs in a permanent form, and when half tones are involved. It consists in printing *direct*, in printer's ink,

from a sheet of gelatine sensitised by bichromate of potash. In photo-lithography the result is not printed direct, but transferred and printed from stone or zinc.

Telegraph School.

Officers, non-commissioned officers, and men are instructed in telegraphy and firing mines by electricity. This portion of the building consists of—(1) The Manipulation Room, with its adjuncts; the Telegraph Office and Battery Room (the latter in the basement). (2) No. 1 Lecture Room for the instruction of men, with its Battery Room adjoining. (3) No. 2 Lecture Room for the instruction of officers and for electrical experiments, with the Electrometer dark room adjoining. (4) The Electrical Workshops. (5) At the back of the Institute are sheds for engines and dynamo machines for electric light.

The instruments taught are A B C, Morse Sounder, Recorder, and Single Needle. The telegraph office contains the instruments on the working postal and military circuits. The lines in connection—(1) Postal Telegraph, connected with the lines of the country through the Chatham head office. (2) A B C, Post Office line of stations, including Convict Prison and Ordnance Stores. (3) Sounder lines to Submarine Mining Training Ship and to Wouldham Pontooning Camp. A fire alarm system is worked here, and tested by means of a microphone, attached to the bell of the waterworks, transmitting the sound to a telephone in the office.

In No. 1 Lecture Room the men are instructed in making up and maintaining batteries, tracing and connecting instruments, finding out faults in lines and instruments, and in the theory of electricity, as far as is desirable for practical work; also in the methods of firing mines by means of electricity, connections, and testing of fuses, and handling of dynamo exploders.

No. 2 Lecture Room is reserved for the instruction of officers and any men who are required to attain a more perfect acquaintance with electrical work than is required in ordinary practice. The instruments kept here include the most sensitive form of Thomson's reflecting galvanometer and electrometer—the latter kept in an adjoining dark room; also a large Holtz machine, from which a six-inch spark can be easily obtained.

The instruction of officers, of course, comprises more theory than that of the men, and is intended to fit them to take charge of the ordinary electrical work of the corps, and to exercise an intelligent supervision over it.

In the attached Signalling School the officers and men are instructed in the method of army signalling common to the whole service, the patterns of flags, lamps, and heliographs employed being identical.

In the electrical workshop all the repairs of the instruments of the electrical, chemical, and surveying schools are carried out; men are trained for the repairs for the Submarine Mining Companies, and undergo a preliminary training for postal telegraph repairs.

Chemical Laboratory.

Officers and military foremen of works are here put through a short course of practical chemistry, especially with the view of learning the properties of limes, cements, and other building materials.

FIELD WORKS, Etc.

Place.	Nature of Work.	Detail of Work.	Remarks.
Workshops	Wood-cutting machinery at work.	Various	Most of the wood-cutting machinery is such as would be used in the R.E. Park at a siege, driven by Steam Sappers.
Upper Model Shed	Types of Field Redoubts to resist Light Field Artillery. Scale $\frac{1}{8}$.	Half-closed works—	
		Stockaded gorge	Working party averages 340 men per relief—3 reliefs of 6 hours each.
		Garrison—half battalion	
		Earth parapet gorge	Working party averages 270 men per relief—3 reliefs of 6 hours each.
		Garrison—half battalion	
		Earth parapet gorge, no material available for blindages, etc.	
		Garrison—quarter battalion	
,, ...	Siege battery for 4 guns ...	... ...	First night—bombproof trench, 87 men, 8 hours. Second night—gun portion, etc., 318 men, 8 hours.
,, ...	Village placed in state of defence.		
Lower Model Shed	1st Parallel	Common trenchwork	Thrown up in 3 reliefs by men at 5ft. apart.
,, ...	2nd do., and approach ...	Flying trenchwork	Thrown up in 3 reliefs by men at 4ft. apart first relief, and at 5ft. apart second and third reliefs.
,, ...	3rd do., and approaches ...	Shallow standing or kneeling, and deep sap	Standing sap—6 men, 4 to 8ft. per hour. Kneeling sap—8 men, 6 to 12ft. per hour. Deep sap—8 men, $2\frac{1}{2}$ to 5ft. per hour.
,, ...	Crowning of covered way	Double sap and crowning sap	16 men, $2\frac{1}{2}$ to 5ft. per hour.
Bridges	Single lock, double lock, single sling, treble sling, and trestle. Scale $\frac{1}{4}$.		
R. E. Park	Trench tramway and rolling stock	18in. gauge, 36lb. iron rail.	
,,	Service pontoons	Weight 7 cwt.; buoyancy 13,000 lbs.	Length. ft. in. — Weight. lbs. ozs.
,, ...	Intrenching tools ...	Service pick	2 11 — 7 9
		,, shovel	3 4 — 5 2
		Light pick	2 6 — 3 6
		,, shovel	2 10 — 3 4

FIELD WORKS, Etc.—*Continued.*

Place.	Nature of Work.	Detail of Work.	Remarks.
			Length. ft. in. / Weight. lbs. ozs.
R. E. Park	Intrenching tools ...	Combined pick and shovel (Vogel and Noots)	
		Roumanian shovel	1 9 / 2 4
		Wallace intrenching tool	1 8 / 1 12
		Cavalry pioneer equipment, of one troop.	1 11 / 2 3
Main Ditch	Brushwood	Men at work making gabions, fascines, etc.	
		Brushwood gabion...	Weight, 36 to 50 lbs.
		Jones's iron-band ditto	,, 30 lbs.
		Sebastopol ditto	,, ,,
		Wire-netting ditto...	,, 16 to 20 lbs.
		Sheet-iron ditto	,, 26 lbs.
		Canvas ditto.	
,, ...	Demolition of railway ...	b. double-headed rail broken with gun-cotton	Charge, 11 oz.
New Ravelin	Use of spars	Men of "A" Troop at work, and raising sheers, derricks, gyns.	
,, ...	Bridging	Single lock	30 men, 2 hours.
		Double ,, ...	36 ,, 3 to 4 hours.
		Single sling	40 ,, 4 hours.
		Treble ,, ...	40 ,, 10 ,,
		Suspension	20 ,, 16 to 20 hours.
Black Lion Field...	Siege battery, 4 guns ...	Guns of siege train in position	8 in. R.M.L. howitzer of 70 cwt. 8 in. R.M.L. howitzer of 46 cwt 6·6 in. R.M.L. howitzer of 36 cwt.
Right Face of New Ravelin at 2.30 p.m.	Mine of attack	Fire mine of attack, and form lodgment	Charge, ½ L.L.R.$_3$ = 1,000lbs. powder.
Gillingham Face at 4 p.m.	Breaching stockade	Stockade of 12in. to 14in. timbers	Charge of gun-cotton, 3 lbs. per foot run.
In front of Memorial Arch, at 4.45 p.m.	Procession of Steam Sappers	No. 2 Steam Sapper, 6 H.P., weight 5¼ tons—3 tenders, siege material, ladders, sandbags, ropes, etc. No. 13 Steam Sapper, 6 H.P., weight about 7 tons—4 tenders, R.E. Park equipment, portable bench, field forge, tool boxes, etc. No. 8 Steam Sapper, 6 H.P., weight about 8 tons (crane, road roller)—mortar or light gun on crane, and 2 tenders, with R.A. stores. No. 21 Steam Sapper, 9½ H.P., about 8 tons—train of 4 siege guns.	

On arrival at the barracks, the members, associates, and other visitors were received by the President, and were by him presented to Sir Evelyn Wood, and to Colonel Harvey, R.E., Acting-Commandant, and having then grouped themselves according to the instructions already alluded to, the programme was carried out with the utmost precision and to the entire comfort and satisfaction of the guests.

In addition to an officer of the Royal Engineers, a Member of the Council accompanied each group.

The lecture delivered by our member, Major Armstrong, R.E., on "Submarine Mining," is, by the permission of the military authorities, included in this number of the Journal, and will doubtless be read with interest by those members who were unable to be present on the occasion.

By the excellence of the arrangements, and the extreme courtesy and attention of those officers of the Royal Engineers who so kindly accompanied the several groups and explained the different operations and exhibits, the day's proceedings were pronounced by all present as most enjoyable, and the President is to be congratulated on the success of the very appropriate entertainment afforded by him to the Society.

SUBMARINE MINING.

By Major ARMSTRONG.

Read at a Special Meeting of the Society held at Chatham on July 11*th*, 1882.

In attempting to give a very condensed account of our electrical work at the School of Submarine Mining, Chatham, to a scientific body containing many members of distinguished ability as public speakers, I claim the indulgence of my hearers in what is to me a difficult and unfamiliar duty.

Our electrical work at this school consists in instruction of officers and men in military telegraphy, of which visual signaling is made a branch; in firing land mines; and, lastly, in the new and important art of submarine mining. The electrical staff of the school also act as the executive of the Royal Engineer Committee, in working out most of the earlier stages of the improvements or new patterns of apparatus, or new methods of working required in the progress of the above-mentioned arts.

As regards military telegraphy, you have had, at different times, papers before you on this subject by experienced officers and other gentlemen; and I do not propose to do more than allude to the benefit obtained by practice in the postal telegraph system of this country, which improves and establishes the efficiency of the telegraphers in what they have learned here.

There are features of the postal telegraph system of working which are not as well adapted for military telegraphy as for commercial and economical telegraphy, but the gain on the whole to the efficiency of our service is so great that I should be glad to see the same system of co-operation between military and civil work introduced into our great outlying dependency, India, where the want of such a system is very clearly shown in the paper read before you by Mr. Luke last year.

As regards military mining, the apparatus is of the most simple character; and I think you will all agree with me that the simpler electrical arrangements can be made for field use the better.

In order to avoid confusion in the two systems of electrical firing employed, the two classes of apparatus are coloured accordingly.

White means low tension.
Black means high tension.
Blue means submarine mining use.
Red means for gun-cotton.

The electric light, which forms such an engrossing subject to the public generally just at present, is also of importance for the defence of fortresses; its use is so much affected by mist and smoke that its value is considerably diminished thereby, yet it cannot be neglected, and we have had a couple of years ago some extensive experiments to determine what apparatus was best for our purpose. This question we are now reconsidering, with the aid of the suggestions offered in the Paris and Crystal Palace Exhibitions.

We are also considering the economical question of barrack lighting by electricity, and I have little doubt that in certain cases it will be a distinct economy. You will see different patterns with which we are experimenting, in the shed at the back of the building.

The absence of novelty in the War Department exhibit at the Crystal Palace has been commented on in one electrical paper. As regards this, I would remark that it is undesirable to exhibit in public, for the benefit of other nations, novelties in our preparations for war, so long as we can keep them secret; and the more important the novelty, the more desirable it is to maintain secrecy. Such a course no doubt renders an exhibition less interesting, and the task of a lecturer (so to speak) more difficult; but I feel sure that the good sense of a patriotic body will acquiesce in the principle. I do not think that anything can be pointed out which has been devised by the general public, and which is suitable for military work, without being taken up; and, as I have said, those points which our own officers originate, it is not desirable to publish, even though the pecuniary interests of the individual may suffer.

I now pass on to submarine mining, and hope that, considering the importance of the subject, a short account of that portion of our work will be found interesting.

Submarine mines, and their coadjutors, torpedoes, were first employed with effect in the American Civil War, which lasted

from 1862 to 1865. The Russians had indeed, in 1854, essayed their use, but with such small charges that no serious injury was occasioned to our vessels thereby, although it must have been clear to those who thought over the matter even then, that with larger charges the results would have been very different.

It was, however, by the destruction of the Federal ironclad gunboat "Cairo," on the 17th December, 1862, that it was first shown that these agents had entered the sphere of practical tactics.

The importance of the part which they were destined to play in future operations was shown by the destruction of 25 vessels and the injury of 9 vessels on the Federal side by their means; and the progress of the art during the American Civil War may be illustrated by the fact that 12 vessels were destroyed and 4 injured during the four months ending April, 1865.

Great, however, as was the physical effect, the moral effect was probably even greater.

Those who have had to encounter these agents speak in the strongest terms of their depressing effect on the nerves of men who are liable to sudden and wholesale destruction by their action; and it will be remembered how the French naval superiority in the Franco-Prussian War was paralysed by the existence, or reputed existence, of mines in the Danube. I use the words "reputed existence" to cover one suggestion advanced, to the effect that during the war just referred to the Danube was practically undefended, only dummy mines having been laid out, supported by stringent cautions issued to the masters of the vessels navigating the river.

Whether that story be true, untrue, or an exaggeration, the great importance of the use of these mines is universally conceded, and indeed is unquestionable.

As regards the introduction of this most important system of defence into this country, I find, in the proceedings of the Committee on Active Obstructions, dated July, 1868, that a memorandum by Sir John Burgoyne (who had with his usual sagacity ever since the Crimean War seen the importance of the matter) served as the basis of the investigation which resulted in the

recommendation of certain main lines for guidance in these operations.

Professor F. A. Abel, chemist to the War Department, and a past President of this Society, who doubtless had been thinking of the matter for some time previously, and whose connection with the progress of the art has never ceased, submitted, in 1864, to the above Committee, designs for an electric-contact mine.

He was shortly followed by the late Col. Fisher, R.E., with a proposal for dual mines, and by others.

The working out of the details of our present system was started in 1870, by a mixed committee under the presidency of an Engineer officer, and consisting of the War Department chemist, a lieutenant Royal Navy, and the electrical staff of the School of Military Engineering, Chatham, who acted as the executive of the Committee, assisted by Lieut. Langdon, R.N., and Mr. E. O. Brown, one of Professor Abel's assistants.

The example set by England was soon followed by all civilised nations, and the young and deadly art has grown with great rapidity under the fostering co-operation of those nations, who may at any moment fly at each others throats.

Yet it must not be supposed that its growth, however peaceful, has been uneventful.

For instance, the entire establishment of the Argentine Republic was blown up—how, no one knows exactly, as no one of those in the place at the time escaped. Captain Harvey, a retired naval officer, whose name will be well remembered in connection with his towing torpedo, who was the officer in charge, was fortunately "out" at the time, and thus escaped.

Again, the first nucleus of an establishment started by the Indian Government, some five or six years ago, was destroyed with all hands during some operations on the Hooghly.

Again, the recent accident to the "Cerberus" in Australia, in which a boat's crew were blown up, will be in the recollection of most here; nor is it to be supposed that the countries I have mentioned have been the only sufferers in the way described. Russia, France, and Germany have also had their fatal accidents.

I have not got a complete record even of the fatal accidents at home and abroad, but I have doubtless said enough to show the necessity for basing this art of defence on accurate principles, or in fact making it a science as well as an art; and to this object, as well as to the training of the requisite men for defence, and the improvement of the material and methods of working, our efforts for the past twelve years have been directed.

Our condition at present is as follows, viz.:—Five companies of Royal Engineers, 469 men in all, are told off for the defence of the naval ports at home and abroad, and for the training depôt.

In the defensive operations they will be aided by certain Engineer Militia of the district, trained for the purpose. For the commercial harbours it is proposed to raise Volunteer corps. They will be assisted by picked men from the practised companies, Royal Engineers.

It will be seen that this portion of our defensive organisation is in strict harmony with the general system now adopted in our army, by which the defence of the country is as far as possible thrown on the Militia and Volunteer forces.

Taking a position, as these mines do, in the first line of defence of the country, it is of the utmost importance at the present age, when attack is delivered with such rapidity, that defence should be always either active, or in such a condition that it could be very rapidly made so.

As will be presently explained, however, the bulk of our mines are either buoyant themselves or are connected with other buoyant apparatus moored below the surface of the water; and in order that such a mine may be able to remain efficient for months while exposed to action of the stream and waves and the blows of passing vessels, it must either be very substantially (*i.e.*, expensively) moored, or great care must be taken in the adjustment of the different details, so as to get the full efficiency out of a lighter and cheaper apparatus.

The expense which would have to be incurred in laying out mines in time of peace, which would remain always ready for action in time of war, as well as the obstruction such a system would cause to traffic, renders it necessary to adopt the cheaper

method, in which mines and moorings of a less permanent character are used. Yet, as nearly everything can be kept ready prepared, there should be no delay on declaration of war in at once commencing to lay down the mines for the defences of the ports, and previous preparation and drill can be carried out to such an extent that, with the detachment told off for the defence of a port, 100 mines could be laid out in four days.

For important ports, some temporary and still more rapid defence would be made in advance of the regular system, under cover of which the other operations could be carried on.

Should, however, the stores at a station be unprepared, it would take weeks, if not months, to get an effective defence laid out, and if in addition to neglect of preparation of the material were added neglect of drill, very few mines would be laid out, and those that were placed would be unreliable as a protection to the port, and dangerous to the detachments laying them.

Having stated what is our position as regards men for this branch of our defences, I will now briefly call your attention to the material.

The art of the destruction of vessels by the explosion of large masses in the vicinity of the weakest portion of the shell (*i.e.*, below the water line) naturally subdivides itself into two, in one of which the destroying engines attack the ships. These are called torpedoes, and are in the hands of the navy: they may be classed with artillery as a portion of the *active* defence.

The second class, or *passive* defence, are called submarine mines. Their function is similar to the advanced land mines of a fortress: they remain quiescent until the enemy advances into their neighbourhood, and then they are exploded. They naturally are managed by the fortification branch of the army, *i.e.*, the Royal Engineers.

However interesting and important may be the various species of torpedoes, such as drifters, spar torpedoes, electrically steered torpedoes, and Whitehead torpedoes, they are the business of the Navy, and the time is too short to discuss them now, and we will pass at once to submarine mines.

A submarine mine is a large charge of explosive material resting passively in the path of an attacking ship.

Mines may be either what is known as mechanical or electrical. The former have the advantage of being the simpler and cheaper, but they have the very glaring defect of being unable to discriminate between friend and foe, and are therefore a bar to traffic where they are employed, from which it results that they should not be used in or on the borders of the channels necessarily kept open to the vessels of the defence and the trade of the port. They have also the further disadvantage, that when they shall be damaged by the enemy's countermines, etc., the defence will be unaware of the fact, and even if it were possible for them to have information on the point, they could not enter a mechanical mine field for the purpose of replacing those mines which were damaged.

Electrical mines, on the other hand, can be rendered perfectly harmless to their friends, thus interfering little with the trade of the port; further, if the enemy succeeds in damaging them, the fact can be ascertained by electrical tests from the shore, and the faulty mines be replaced.

Electrical mines are divided into two classes, viz., contact mines (*i.e.*, those which are exploded by the action of the attacking vessel), and observation mines (*i.e.*, those which are fired by one or more observers on shore, when it is judged that the vessel is within their range).

The contact mines contain 100 lbs. of gun-cotton, which is sufficient to make a hole ten to twelve feet square in the bottom of our modern ironclads.

The observation mines contain 500 lbs. of gun-cotton, and are laid in about 40 to 50 feet of water, on the bottom if possible, for mines on the bottom produce a greater upward effect than those which have any depth of water cushion underneath. They will damage, according to the experiments made on the "Oberon" (an old ship plated for the purpose), the machinery of a vessel at a horizontal distance of about 30 feet—that is to say, adding 20 feet for the half beam of the vessel itself, one of these mines would guard an area whose diameter is 100 feet.

At first sight it would appear that such mines would form a much more efficient and cheaper system of defence than the electric-contact mines, which are only efficient against vessels which strike them; but there are so many atmospheric conditions

during which observation mines cannot be used, that the contact mine forms the mainstay of our present systems of defence. For instance, one cannot observe in a fog or by night without the use of the electric light, which is itself a mark for the enemy's fire, while the smoke from the guns of both attack and defence acts as a screen, which its beams cannot penetrate effectually, if at all.

The explosive, if I may so call it for the moment, employed is compressed gun-cotton, and our possession of such a suitable agent is one of the points in which we are solely indebted to Professor Abel's researches and exertions—that is to say, that although gun-cotton was discovered as an explosive previously, it has been made a practical and useful agent for our purposes by Professor Abel's investigations, by which its purity and consequent safety have been insured, and its density and consequent great power have been arrived at.

Its advantages are, as I have said, great power in a small space, even when unconfined, and safety and convenience in handling, and to these have been added more recently complete safety in storage.

For instance, this ounce of dry gun-cotton, which, if simply ignited by flame, burns so harmlessly away, can by the action of a small charge of fulminate of mercury be made to detonate even without confinement, producing enormous destructive effect.

The noise would be too great for detonating it with comfort in this room, but the effect can be judged from the detonation of $\frac{1}{16}$ of the weight of fulminate of mercury, which is the amount contained in the service detonating fuse, on which determines the detonation of the whole mass.

The possession of great power in small bulk and weight is of first-class importance for any work which has to be quickly done, and this is more especially the case in working in rough waters and strong tideways. The fact that the effect is developed with great rapidity and without confinement gives gun-cotton a further grand advantage over the more familiar gunpowder, which must, on the one hand, be confined in strong heavy cases, and, on the other, will lose much of its effect through the water entering before the whole charge is ignited.

The advantage of safety in storage is obtained from the

capability of this substance of developing its full power while wet. The bulk of the charge is therefore never dried, and may be treated with impunity in a manner which wonld not be safe with gunpowder.

Our present limited time and space prevent the exhibition of any great amount of detail; however, I dare say the arrangement by which, on the one hand, mines can be made to fire automatically by the enemy's vessels, and, on the other, can be rendered safe for the passage of friends when desired, will be of interest to those who have not already seen it.

Here is what is called a circuit-closer—that is, in this case, an apparatus fitted with an inertia ball, and enveloped in a water-tight case, and in connection with the shore by a light armoured electric cable. On the case being struck by a passing vessel, the inertia ball makes contact against a spring, thus closing a circuit through the electric fuse. If the firing battery were attached direct to the cable which is connected with the mine, the latter would be fired at once by the closing of the electric current.

As a matter of fact, however, the firing battery is never connected direct to the cable for a longer time than is necessary to fire a mine, inasmuch as some of the cables are sure to be leaky from wear and tear, and there would be rapid deterioration of any powerful low resistance battery yet found suitable for the work, if left to work continuously in the way described. The firing is therefore effected by relays, which are technically called shutters. The shutter apparatus consists of an electro-magnet, with a centrally pivoted armature, which on being worked by a sufficiently powerful current releases the shutter, which drops down. The shutter is connected permanently to line, and in the first position is joined to the signalling battery and electro-magnet coils, and in the second position to the firing rail, to which the firing battery can be connected either permanently or at any desired moment.

You will, I hope, see a 100 lbs. mine fired in this way at four o'clock. A small vessel will run at a circuit closer, in this case at some distance off, and on completing the circuit the mine will be fired.

RULES REGARDING THE AWARDING OF PREMIUMS.

The Council have determined that the Society shall offer three premiums annually for the best original paper sent in to the Society, on Telegraphic or Electrical subjects, during the session, by any person not being a member of the Council of the Society.

The 1st Premium will be called the Society's Premium, value £10.

The 2nd Premium will be called the Paris Electrical Exhibition Premium, value £5.

The 3rd Premium will be called the Fahie Premium, value £5.

The awarding of the premiums will rest with the Council, to whom power is reserved of declining to award either or any of the said premiums in any year in which they may consider the papers offered as unworthy of the distinction.

The premiums will consist of Books or Scientific Apparatus.

No person will be entitled to receive more than one of the said premiums in any one year.

The first premiums will be awarded in 1883, for the best papers sent in between this date and the end of May next.

By Order. F. H. WEBB,
Secretary.

May 25, 1882.

Society of Telegraph Engineers and of Electricians.

RULES AND REGULATIONS

FOR THE PREVENTION OF FIRE RISKS ARISING FROM ELECTRIC LIGHTING,

Recommended by the Council in accordance with the Report of the Committee appointed by them on May 11, 1882, to consider the subject.

MEMBERS OF THE COMMITTEE.

Professor W. G. Adams, F.R.S., *Vice-President.*

Sir Charles T. Bright.

T. Russell Crampton.

R. E. Crompton.

W. Crookes, F.R.S.

Warren De la Rue, D.C.L., F.R.S.

Professor G. C. Foster, F.R.S., *Past President.*

Edward Graves.

J. E. H. Gordon.

Dr. J. Hopkinson, F.R.S.

Professor D. E. Hughes, F.R.S., *Vice-President.*

W. H. Preece, F.R.S., *Past President.*

Alexander Siemens.

C. E. Spagnoletti, *Vice-President.*

James N. Shoolbred.

Augustus Stroh.

Sir William Thomson, F.R.S., *Past President.*

Lieut.-Colonel C. E. Webber, R.E., *President.*

These rules and regulations are drawn up not only for the guidance and instruction of those who have electric lighting apparatus installed on their premises, but for the reduction to a minimum of those risks of fire which are inherent to every system of artificial illumination.

The chief dangers of every new application of electricity arise mainly from ignorance and inexperience on the part of those who supply and fit up the requisite plant.

The difficulties that beset the electrical engineer are chiefly internal and invisible, and they can only be effectually guarded against by "testing," or probing with electric currents. They depend chiefly on leakage, undue resistance in the conductor, and bad joints, which lead to waste of energy and the production of heat. These defects can only be detected by measuring, by means of special apparatus, the currents that are either ordinarily or for

the purpose of testing, passed through the circuit. Bare or exposed conductors should always be within visual inspection, since the accidental falling on to, or the thoughtless placing of other conducting bodies upon such conductors might lead to "short circuiting," or the sudden generation of heat due to a powerful current of electricity in conductors too small to carry it.

It cannot be too strongly urged that amongst the chief enemies to be guarded against, are the presence of moisture and the use of "earth" as part of the circuit. Moisture leads to loss of current and to the destruction of the conductor by electrolytic corrosion, and the injudicious use of "earth" as a part of the circuit tends to magnify every other source of difficulty and danger.

The chief element of safety is the employment of skilled and experienced electricians to supervise the work.

I. The Dynamo Machine.

1. The dynamo machine should be fixed in a dry place.
2. It should not be exposed to dust or flyings.
3. It should be kept perfectly clean and its bearings well oiled.
4. The insulation of its coils and conductors should be perfect.
5. It is better, when practicable, to fix it on an insulating bed.
6. All conductors in the Dynamo Room should be firmly supported, well insulated, conveniently arranged for inspection, and marked or numbered.

II. The Wires.

7. Every switch or commutator used for turning the current on or off should be constructed so that when it is moved and left to itself it cannot permit of a permanent arc or of heating, and its stand should be made of slate, stoneware, or some other incombustible substance.

8. There should be in connection with the main circuit a safety fuse constructed of easily fusible metal which would be melted if the current attain any undue magnitude, and would thus cause the circuit to be broken.

9. Every part of the circuit should be so determined, that the gauge of wire to be used is properly proportioned to the currents it will have to carry, and changes of circuit from a larger to a smaller conductor, should be sufficiently protected with suitable

safety fuses so that no portion of the conductor should ever be allowed to attain a temperature exceeding 150° F.

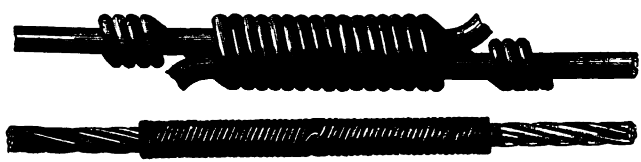
N.B.—These fuses are of the very essence of safety. They should always be enclosed in incombustible cases. Even if wires become perceptibly warmed by the ordinary current, it is a proof that they are too small for the work they have to do, and that they ought to be replaced by larger wires.

10. Under ordinary circumstances complete metallic circuits should be used, and the employment of gas or water pipes as conductors for the purpose of completing the circuit, should in no case be allowed.

11. Where bare wire out of doors rests on insulating supports it should be coated with insulating material, such as india-rubber tape or tube, for at least two feet on each side of the support.

12. Bare wires passing over the tops of houses should never be less than seven feet clear of any part of the roof, and they should invariably be high enough, when crossing thoroughfares, to allow fire escapes to pass under them.

13. It is most essential that the joints should be electrically and mechanically perfect. One of the best joints is that shown in the annexed sketches. The joint is whipped around with small wire, and the whole mechanically united by solder.



14. The position of wires when underground should be efficiently indicated, and they should be laid down so as to be easily inspected and repaired.

15. All wires used for indoor purposes should be efficiently insulated.

16. When these wires pass through roofs, floors, walls, or partitions, or where they cross or are liable to touch metallic masses, like iron girders or pipes, they should be thoroughly protected from abrasion with each other, or with the metallic masses, by suitable additional covering; and where they are liable to abrasion

from any cause, or to the depredations of rats or mice, they should be efficiently encased in some hard material.

17. Where wires are put out of sight, as beneath flooring, they should be thoroughly protected from mechanical injury, and their position should be indicated.

N.B.—The value of frequently testing the wires cannot be too strongly urged. It is an operation, skill in which is easily acquired and applied. The escape of electricity cannot be detected by the sense of smell, as can gas, but it can be detected by apparatus far more certain and delicate. Leakage not only means waste, but in the presence of moisture it means destruction of the conductor and its insulating covering, by electric action.

III. LAMPS.

18. Arc lamps should always be guarded by proper lanterns to prevent danger from falling incandescent pieces of carbon, and from ascending sparks. Their globes should be protected with wire netting.

19. The lanterns, and all parts which are to be handled, should be insulated from the circuit.

IV. DANGER TO PERSON.

20. To secure persons from danger inside buildings, it is essential so to arrange the conductors and fittings, that no one can be exposed to the shocks of alternating currents exceeding 60 volts; and that there should never be a difference of potential of more than 200 volts between any two points in the same room.

21. If the difference of potential within any house exceeds 200 volts, whether the source of electricity be external or internal, the house should be provided outside with a "switch," so arranged that the supply of electricity can be at once cut off.

By Order of the Council.

F. H. WEBB, *Secretary.*

Offices of the Society,
4, The Sanctuary, Westminster,
June 21, 1882.

ORIGINAL COMMUNICATIONS.

MICHEL GLOESENER.

By V. H. P. Caillard, Lt. R.E., Assoc. Mem. S.T.E.E.

[*The following article has been compiled from authentic Manuscripts by M. Gloesener, bearing the dates* 20*th August*, 1842, *and* 24*th June*, 1848, *and from Biographical Notices by François Folie (F. Hayez, Brussels,* 1878) *and Alphonse le Roy (Carmanne, Liége,* 1869), *kindly placed in my hands by* Lt.-Col. Webber, R.E., *President of the Society.*—V. Caillard, Lt. R.E.., A.M.S.T.E.E.]

It is the fate of most great discoverers to see their discoveries at first coldly received, and afterwards, when their true value has been recognised, quietly appropriated by somebody else as the work of his own brain.

There is no theft, perhaps, more common than this, and certainly there can hardly be any more cruel. Years and years are given to the elaboration of some great theory, or to the invention of some ingenious machine. It is laboriously worked out—it is described and illustrated with painful care—to what end? Often, seemingly, to be consigned to hopeless oblivion in the archives of some scientific society, with perhaps the empty consolation of a bare vote of thanks from the society's committee; possibly without even that. And may be, afterwards, when the disappointed inventor, convinced, nevertheless, that there is a great truth wrapped up in that apparently forgotten paper, has given up all hope of ever seeing his grand discovery come to light, he will suddenly find it staring him in the face at almost every turn, but connected with a name not his own. All those years of labour—all that heart-sickening hope deferred and bitter disappointment—and another is to reap the harvest, and to wear the crown.

M. Gloesener, the great Belgian electrician and physicist, must have had a keen experience of the bitterness of such disappoint-

ment, though no doubt, to some extent, he formed an exception to the rule. Success, and even great success, he did finally obtain, but it was long before he obtained such success as his genius deserved; and even now it would seem as if his greatest discoveries were not at all generally linked with his name. He was one of the first explorers in the field of electro-magnetic research, and, in so far as the advancement of science was concerned, was one of the most successful, as indeed has been fully acknowledged by both Ampère and Morse. It is therefore hoped that, as his fame appears to be but little extended in England, and his merits but very faintly, if at all, recognised, the following account, both of himself and of his first application of one of his greatest discoveries, may be of some interest.

Michel Gloesener,* related on his mother's side to the family of Nothomb, was born at Haut-Charage, in the Grand Duchy of Luxemburg, on March 4th, 1794. He entered young into the Imperial College of Luxemburg, at the head of the list. There his varied and splendid talents already began to show themselves. He never lost the place of first in his class; was "laureate" in poetry, rhetoric, and philosophy; and carried off the prize for special mathematics. During his last year at the college he received the title of "*Conférencier*," which implied the duty of directing the studies of the collegians in poetry.

In 1816, he went to Metz, where he made a special study of mathematics under Lesage. He next underwent a special course of physics, and incidentally a course of theology at Trèves. Finally, in 1818, he entered the University of Liége, and here, whilst preparing himself to obtain the diploma, at that time very rarely bestowed, of *Matheseos Magister et Phil. Naturalis Doctor*, he obtained, in three successive years, three gold medals—one for algebra, one for botany, and the third for chemistry.

In the fourth year, he was again awarded a gold medal for a dissertation on electro-magnetism. But this medal he did not actually receive, out of respect, it appears, to Professor Vander-

* This short biographical notice is taken in great part from that by Alphonse le Roy.

heyden* (Professor Emeritus of the University of Liége, and chairman of the awarding Jury), who pretended to see an act of insubordination in the fact that the competitor had maintained an opinion at variance with his own. Nothing was further from the mind of Gloesener than any idea of insubordination. Such a feeling was indeed foreign to his character; he was merely demonstrating what he considered to be a scientific truth. (It may be noted that from this time forth he devoted his researches more particularly to the science of electro-magnetism.)

In deference, then, to Vanderheyden, he did not receive his fourth gold medal; but that his opinions remained unshaken may be seen from an inspection of his inaugural dissertation, made when he received the doctorate of science (23rd February, 1823), in which he brilliantly supported the ideas of Ampère. Later he had the consolation of receiving hearty encouragement from Ampère himself, and of seeing the theories which he sustained accepted as true by all men of science.

Before undergoing his last examination, he went to pass some time at Utrecht. But, being disappointed in the scientific resources of the place, he returned in order to obtain his diploma, and subsequently went to Paris, in the full assurance that on his return he would receive an instructorship in the higher branches of learning. Upon this career he had set his heart, in spite of the opposition of his family; and, indeed, such an instructorship was promised him by the Belgian Minister, Falck, who recognised Gloesener's claims to the post in a letter, in which he said, "*J'ai rarement vu d'aussi brillants certificats.*"

During the two following years he underwent self-imposed but severe courses of study in almost every branch of science, to follow him in which would take up more space than it would be possible to allow in a notice of this sort. The most interesting facts connected with this period of his life are, perhaps, the friendships which he then formed with Arago and Ampère.

In 1821, the professorship of High Mathematics and of Physics

* Vanderheyden had written a "Mémoire on Electro-magnetic Engines," published in 1822 by Ducrotay, of Blainville.—(François Folie.)

at the Royal College of Bruges had been offered to him, but, his studies not being completed, he declined the honour. In 1824, he was nominated Lecturer to the Faculty of Sciences at the University of Louvain, and there entrusted with the courses of astronomy and analytical mechanics.

On the 28th September, 1825, he accepted a professorship at the Collège Philosophique, and retained that post up to the date of the suppression of the college in 1830.

His definite nomination at the University, as Professor Extraordinary, dates from the 4th October, 1825. The inaugural address which he made on this occasion, entitled, "*De verâ scientias physicas excolendi methodo et vero illarum studii fine*," was pronounced, according to custom, in a solemn sitting of the Faculty, on January 26th, 1826.

He married, in 1828, Mdlle. Marie Barbe Elisabeth Müller, of Saar-Union, whose acquaintance he made at Louvain, at the house of M. Harbaur, the first chief rector of the reconstituted University.

An opportunity occurred in the year 1830 which proved M. Gloesener to be a man of courage as well as of science. The occasion was an episode of the Belgian Revolution, which the Belgian historians can never mention but with a blush of shame.

The house of the Commandant of Louvain, Major Gaillard, which was next to that of M. Gloesener, was broken into and sacked by a furious mob. In spite of imminent personal danger, M. and Madame Gloesener succeeded in saving Madame Gaillard, all her plate and valuables, and even the minutes of the orders of the Netherlands Government. A band of ruffians had meanwhile seized upon the person of the unfortunate Commandant, and by means of excruciating tortures had put him to a slow and agonising death. This barbarous murder had come to the ears of M. Gloesener before Madame Gaillard had obtained any knowledge of it. She was then at the house of one of her friends. Receiving only vacillating answers from the authorities, and seeing the triumph of the revolution, the Professor concerted a plan with Doctor Band, whose courage throughout this affair is also above all praise, and it was agreed that the unhappy lady should return to her former home.

There was not a moment to lose. Everything was to be feared from the state of excitement of the mob. But, on the other hand, it was almost impossible to persuade Madame Gaillard to leave Louvain without giving her some suspicion of the truth. For a long time she hesitated. At last, on the assurance that she was to be taken to her husband at Brussels, where (as she was made to understand) he was to be tried, she consented to go. Accordingly she was conducted to that town, where active steps were taken to provide for the Major's widow, and to enable her to return to France, the land of her birth.

It is easier to imagine than to describe the feeling of gratitude borne by Madame Gaillard towards her deliverers for the rest of her life; "and," says the biographer (Alphonse le Roy), "this sentiment would doubtless have been shared by the Dutch Government had they known the details above described. . . . . It is perhaps owing to his (M. Gloesener's) courage that our revolution was soiled with but one spot of blood."

On the 16th December, 1830, M. Gloesener, although maintaining his position of "Professor Extraordinary," was transferred to the University of Liége. He was entrusted by the Provisional Government with the courses of experimental physics; physics as applied to domestic life, to medicine, and to art; of physical astronomy, and of mathematical physics. After the death of Gaede, at the request of the Faculty of Science, he was with difficulty induced to undertake the course of mineralogy during the academic year 1834-35; but he would not do so permanently, and the instructorship was finally handed over to Lesoinne.

It was at this time that Gloesener made the acquaintance of the eminent geologist, André Dumont, then quite a young man. With him he subsequently went on a geological tour, to the pleasure of which, till the end of his life, Dumont was never tired of referring.

On the 1st September, 1835, the Inspector-General of Artillery, in a letter couched in the most flattering terms, offered M. Gloesener a professorship at the School of Artillery. On the 5th December of the same year, in consequence of the reorganisation of superior instruction (*instruction supérieure*), his duties at the University were again fixed by royal decree—*i.e.*, mathematical physics,

experimental physics, astronomy, celestial mechanics, and physics as applied to the arts.

The year 1837 is a notable one in his life, as being that in which he made the discovery of the principles of the "alternate reversal of the electric current in electro-magnets," and of the application of a magnetised armature to electro-magnets—principles of which innumerable applications have since been made (many, indeed, by himself), but whose real origin is known, I believe, to few.

In 1846-47, he was invested with the rectoral ermine of the University, and on that occasion pronounced a discourse, entitled, "On the Influence of the Study of Physics on the Well-being of Humanity," which was highly appreciated by the most distinguished physicists.

In 1850, M. Gloesener generously consented to a partition of the courses of experimental and mathematical physics, in favour of M. Bède, to whom he afterwards entirely yielded the course of industrial physics. He was authorised on January 7th, 1857, to supervise the course of mathematical physics only. He did not, however, in any way relax his industry; on the contrary, it was at this time that he worked hardest to perfect the applications of science, although he had to undergo the vexations of every description which are the usual lot of inventors.

On the 4th February, 1861, he was declared superseded (*émérite*). This measure, which was a great blow to M. Gloesener, and which deprived him, although he had been an instructor during fifteen years, of the increase of pay accorded to Professors at the University by the law of the 14th March, 1863, was taken with the object of inducing his distinguished successor, M. Pérard, permanently to remain an instructor in the higher branches of science. This object was not, however, attained, for M. Pérard resigned towards the end of the same year, and devoted himself to the work which he was never to leave. It is a strange coincidence that it was in this year that the first volume of M. Gloesener's great work, "Traité Général des Applications de l'Electricité," appeared—a masterpiece which death prevented him from completing, but which will no doubt be completed as a posthumous

work by means of the numerous manuscripts which he has left behind. On the 17th February of the same year, he was elected, by a ministerial decree, to remain in charge of the course of mathematical physics.

On the 16th of the following November, he endeavoured to carry into effect a long-cherished project, which was to induce the Faculty of Sciences to provide instruments for the students who had entered upon the courses for the doctorate in physical and mathematical sciences, and still more especially for those who had destined themselves to professorships, in order to exercise them in practical manipulation. The Faculty approved of the idea; but as there would have been some slight expense to the State, the Government refused to be persuaded, and the project, of necessity, fell to the ground.

In 1864, he became a member of the Academy (Belgium), of which he had been elected a correspondent in 1856. In 1874, the Academy adjudged to him the quinquennial prize for physical and mathematical sciences, in recognition of the original works which he published in its bulletins, and which referred entirely to new ideas and ingenious inventions, more especially in telegraphy, of which a slight mention is made below.

In 1875, he was, to his intense and most legitimate satisfaction, made vice-director of the Academy for the year. But he did not live to enjoy this distinction long. On the night of the 10th June, 1876, he succumbed to an illness which had for some time been threatening him, and died at the advanced age of eighty-two.

In addition to his great natural genius, M. Gloesener appears to have possessed in a marked degree the qualities of concentration and application, together with a vast capacity for work. His energy of character was such that no danger or obstacle could prevent him from responding to the call of what he considered his duty. At the age of eighty years, when starting for Vienna, where cholera was raging, to take part in a meteorological congress, his friends endeavoured to dissuade him from his purpose, and represented to him the danger of the journey. His answer was characteristic: "J'ai accepté la mission de représenter la Belgique au congrès météorologique, *et je m'y rendrai.*"

His inventions and published works are themselves so numerous that a list of them would fill several pages; and even when not actually writing, inventing, or teaching, he seems to have been continually thinking. He appears by mere force of thought to have conceived the great and yet simple idea of the reversal of the electric currents in electro-magnets, and of the substitution of permanently magnetised armatures (applied by him first in telegraphic instruments) for the ordinary armatures of soft iron. He turned his attention, with never-failing scientific, though often unrecognised, success, to every department of electrical mechanics. Telegraph instruments, chronoscopes, electro-magnetic mariner's compasses, methods for counteracting the effect on compasses of iron in ships, electrical clock systems—these are but a very few of the products of his fertile inventive genius.

In the Exhibition at Paris of 1867, amongst numerous systems of telegraphy invented and constructed by M. Gloesener to fulfil different requirements, and all including the principle of the reversal of the electric current (the double-current system), and the suppression (by means of the magnetised armature) of the antagonistic spring in the receivers, were shown in the telegraphic department, needle instruments, dial instruments (*à clavier*), and a new model instrument for continental and submarine telegraphs, registering despatches with two ink-writers instead of one, and thus doubling the rapidity of transmission. He showed also a system of electric clocks working on the same principles, and various electric chronoscopes; more especially a large chronoscope capable of registering $\frac{1}{10000}$ of a second, of aiding in the determination of terrestrial longitudes, and of recording various physical phenomena.

These exhibits drew on him the warmest commendation and praise from every member of the Jury, though unfortunately he was even then unable to reap the substantial success due to him, on account of the delay in the arrival of one of the boxes containing his apparatus.

One of M. Gloesener's first applications of his greatest discovery (already several times referred to) is well and concisely described by M. Pérard, in a speech made in honour of the great *savant* after

his death.* I cannot perhaps do better than give a literal translation of extracts from that speech :—

"It was only necessary to think of it! But in that lies all the genius.

* * * * * * *

"It needed only, Messieurs, to think of that! That is the fortunate observation which lightened the path trodden by Gloesener with so admirably methodical a step, and which has saved (the word is none too strong)—which has saved the electric telegraph.

"He would not lose his time in meddling with details of mechanism. He distinctly puts this problem: The armature must oscillate naturally by the impulsion of one sole force, and that force must be none other than the electric current.

"In other words, the elasticity—that is to say, the antagonistic spring, that very appliance which till then had been regarded as essential—must be eliminated.

"By means of his long experience in the art of combining apparatus for the purpose of demonstration, Gloesener was prepared to solve the problem to the last degree of perfection. What will he do in order to realise his precious idea, and exactly follow the indication of nature, which he had so well observed? Instead of a single electro-magnet, there are to be two, placed one in the prolongation of the other, and leaving between their neighbouring extremities, or poles, a space in which the armature may execute its come-and-go.

"This armature is no longer to be of ordinary iron. It will be a blade of steel, permanently magnetised to saturation.

"The helices will be wound round two electro-magnets in such a way that, by virtue of the same electric current, taken from the same source, the opposed poles act together—one by attraction, the other by repulsion—on the steel armature, so that both cooperate in producing the same beat.

"Then the current is stopped, reversed, and, passing through the helices in the opposite direction, destroys the residual

---

* "Derniers honneurs rendus à M. M. Gloesener."—(J. Desoer, Liége, 1877.)

magnetism, and produces an inverse magnetisation to the first. The pole, then, which had attracted, now repels, and *vice versâ.*

"The return beat (*le battement retrograde*) is thus secured by the co-operation of two electro-magnets, deriving from the same source a double energy, which for each oscillation remains constant, whatever may be the accidental or normal variations of the pile, during a series of oscillations."

In fact, M. Gloesener had contrived to eliminate entirely the antagonistic spring, and to construct a constant and extremely simple instrument, requiring no regulation.

It may be interesting to note that the priority of the introduction of this system into the public service may be ceded to Mr. Varley, who, in 1854, or towards the end of 1853 (long after the date of Gloesener's discovery), applied an arrangement of his invention to work the writer of the Morse recorder by means of the alternate reversal of the electric current.

It is purposed to give now as full a description as space will allow of the first application which M. Gloesener himself made of this principle. This description is a summary, in fact almost a literal translation, of one of the manuscripts of M. Gloesener which Lieut.-Colonel Webber has been kind enough to place in my hands. It is dated 1842, five years after the discovery itself. It is hoped that, although all the principles contained in it are now so well known that to many they may hardly seem worth describing, yet it may afford some interest, as showing to whom the honour of the priority in this field of research is due.

It should be remarked that in the following, where the quotations are not actually *verbatim*, the arguments and conclusions are none the less those of M. Gloesener himself.

On the 20th August, 1842, M. Gloesener forwarded to the Minister of the Interior of Belgium a paper describing his new invention, which was entitled, "A new system of electro-magnetic motors intended to replace steam-engines, water-engines, and motors of any sort whatever, and called 'oscillatory electro-magnetic motor,' or, shortly, 'oscillatory motor,' or, still better, 'electro-magneto-oscillatory motor.'"

In the covering letter accompanying this paper, M. Gloesener

sets forth that he is forwarding a sealed packet containing the principles and scheme of a new motor system, capable of replacing other motors of whatever sort; and he asks for a patent, his end being, he says, "to secure to myself the priority of a discovery on which I am still engaged." He goes on to say, that although in the sealed packet sufficient details will be found, as to the construction of the machine, to enable a mechanician to execute it perfectly and without any trouble, yet he intended to send forward in a short time a still more elaborately developed plan. And, seeing that for the moment his only object in forwarding his paper, was "*to guarantee to himself the priority of the invention of the new motor*," he asks that the sealed packet may not be opened until the further elaboration had been completed.

Passing on now to the paper itself, it may be as well to give the preamble in M. Gloesener's own words. "I have tried," he commences, "two different systems: that of direct rotation, and that of 'come-and-go' (*va-et-vient*). This last system I call *electro-magnetic-oscillatory*, because the throws of the beam (*les excursions du balancier*) are very small, or, electro-magneto oscillatory motor.

"Both theory and experiment have demonstrated to me that this latter system (the oscillatory system) is to be preferred; because the motive force developed by this system produces effects, far more considerable than those obtained by the system of rotation.

"So far as I know, no oscillatory electro-magnetic engine, having the object of replacing steam, or any other motive power, by an electro-motive force, has yet been suggested; and I have the right to consider as *new* that which I propose."

He then proceeds to expose the principles which had enabled him to invent, and caused him to prefer, the oscillatory system of electro-magnetic engines; and which at the same time serve sufficiently to indicate the method of construction of the proposed motor. They are as follows:—

1*st Principle.*—The action of an electro-magnet on a piece of soft iron in contact with it, and of the same electro-magnet on the same iron at different distances, is not governed by Newton's law —*i.e.*, is not in the inverse ratio of the *squares* of the distances.

That reciprocal action decreases in a much more rapid ratio; so that, being very great at the time of contact, it is already quite small at only moderate distances, such, for instance, as from one to one and a half inches.

M. Gloesener made several experiments which he considered to prove that magnetic action decreases more rapidly than in the inverse ratio of the *cubes* of the distances; and to show, that such decrease is greater when the distances are greater relatively to one another, and when the differences between the distances themselves are greater. Thus the magnetic action at sensibly different distances follows no regular law dependent on those distances.

From this ensues the following fundamental deduction: "That electro-magnets, both fixed and movable, should be made to act at distances as small as possible;—in other words: If it be possible, movable electro-magnets should be made to oscillate by means of the influence of others which are fixed.

"This is only possible in a system of 'come-and-go,' and not in a system of direct rotation."

The oscillatory movement could be changed into a rotary, in the usual way practised in steam-engines.

2nd Principle.—In the oscillatory or "come-and-go" system, the forces of the fixed and movable electro-magnets not only act at small distances, but also in the same direction as the motion, and consequently with all their intensity.

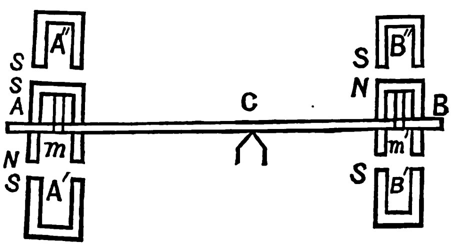
In the system of direct rotation, on the other hand, the nearer the poles of the movable electro-magnets approach to the poles of the fixed electro-magnets, the more oblique does their reciprocal action become. When they are at the smallest distances one from the other,—*i.e.*, when their poles are exactly opposite,—their reciprocal action is at its maximum, but is absolutely useless for producing any movement in the direction of rotation. Nay, that movement is in fact considerably impeded, as the action is then at right angles to the direction of rotation, which latter continues merely by virtue of the impetus already acquired. In the direct rotatory system the forces never act directly, but always obliquely, in the direction of the motion, as can easily be seen by the resolution of the forces along that line.

On the other hand, in the oscillatory system the greatest distance between the opposite poles which are attracting one another could only be a few lines (*quelques lignes*). (It should be well understood that this distance should always be made as small as possible, but large enough to be able to convert the oscillatory movement into one of rotation.)

Take, for instance, a distance of three lines (*trois lignes*). At this distance the reciprocal action of two strong electro-magnets will be very great, and will also be in the direction of motion. This motion once begun, the attraction, and consequently the velocity, increase more and more up to the point of contact. At the instant of contact the polarity is changed (see below), and repulsion commences. The distance between the two electro-magnets having once more reached the extent of three lines, the polarity is again changed,—*i.e.*, attraction is substituted for repulsion,—and thus, by means of the total reciprocal attraction, which always acts in the direction of motion, the oscillatory motion is set up.

3rd Principle.—The effect of the machine will be doubled if the fixed and movable electro-magnets be so arranged that, when one end of the beam is attracted, the other shall be repelled. The intensity of this action can again be doubled by causing each movable electro-magnet to oscillate between two fixed electro-magnets, as shown by the accompanying figure.

FIG. 1.



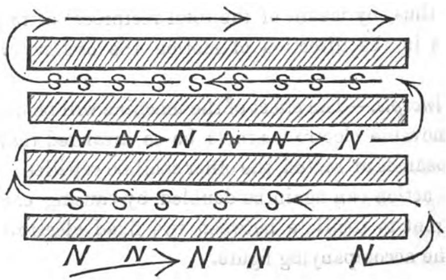
It will be seen that the beam oscillates about the fixed axis, C, that the movable electro-magnet, A, is impelled towards the fixed electro-magnet, A′, by reciprocal attraction, and repelled from A″ by reciprocal repulsion; at the same time the electro-magnet B

is reciprocally attracted towards B″, and repelled from B′. The movable electro-magnets being fixed to the beam itself at *m* and *m′*, all the attractions and repulsions combine to produce the oscillation of the beam; and, these forces being exerted at very small distances, the movement of the latter will be extremely rapid and powerful.

4th Principle.—For simplicity, we have so far considered simple electro-magnets; but, practically, one magnet would be composed of numbers of others.

A piece of very soft iron should be selected, one foot long, from one to two feet broad, and between four and five inches thick. Small trenches or channels should then be traced on it, about an inch and a half deep, or deeper if the thickness should be greater,

FIG 2.



an inch broad, and with an interval of about an inch between them.

In these trenches should be wound a very thick insulated conductor, or a faggot of copper wires, 30 or 36 in number, so that N. and S. poles should be alternately formed, as shown in Fig. 2.

Experiment shows that the effect of such an electro-magnet is enormous.

The magnets (see Fig. 1) should be slightly inclined, in order that at the moment of contact they may touch each other at all points.

The movable electro-magnets should be lighter than the fixed, but of the same form, and rather longer or deeper, and so con-

structed that the poles and "channels" of the fixed and movable electro-magnets should correspond.

(M. Gloesener here reserves to himself the right of employing and combining electro-magnets in such a manner as further experiment might show to be more advantageous, never, however, for an instant moving from his position of regarding the "electro-magneto-oscillatory motion" as that to be preferred. He also reserves his choice of the electric conductor, and the particular mode of employing it.)

5th Principle.—Experiment proves, 1st, that when the current in an electro-magnet is stopped the magnetism developed still partly subsists, and consequently that that subsisting, or residual, magnetism must be an obstacle to the development of the opposite polarity.

2ndly. That magnetism is not developed instantaneously, but only arrives at its maximum intensity after a certain sensible time.

It follows, therefore, that this principle is established: that the direction of the electric current, or, in other words, the polarity, should be changed as seldom as possible in a second of time, but, nevertheless, often enough to give a sufficient velocity. Evidently the advantages resulting from these conditions are greater in an oscillatory system than in a system of direct rotation.

For instance, in the oscillatory system, for one complete revolution the direction of the current must be changed twice; for ten revolutions per second twenty times; for x revolutions $2x$ times, whatever may be the number of movable poles that one employs.

But, in the direct rotation system, in order to complete one revolution, the current must be changed the same number of times as there are electro-magnets; and, since in order to procure any considerable force a sufficient number of electro-magnets must be used, it is evident, in reference to the point in question, that the oscillatory system is to be preferred.

It will doubtless be observed that the two fixed electro-magnets on each side respectively of the beam, not only double (or nearly so) the resultant motion, but also the alternating poles in the beam itself arrive more readily at their maximum of development.

6th Principle.—The principle of changing the electric currents in the movable electro-magnets is as follows:—A commutator (*changeur*) is made by means of a copper disc divided into two parts, separated from one another by an insulating strip of dry wood, or, better still, of glass. This disc is set rotating by means of a crank in connection with the beam. The commutator is placed on a horizontal axis fixed in the vertical plane of the beam, and its movements are regulated in such a way that the current changes direction each time that the movable electro-magnets come in contact with the fixed. Two copper studs rubbing against the commutator lead to it alternately the positive and negative electricity of the two poles of a voltaic pile.

7th Principle.—This principle treats of the multiplication of the electro-magnetic force, and of the velocity of the machine.

If sufficient power were not obtained with a single beam, such as that which has just been described, two, three, or, in a word, a sufficient number, should be established in exactly the same way as has been laid down for one alone. M. Gloesener remarks that he does not consider it probable that more than two would even be found necessary.

As to the velocity, this, he says, on a railway, could be increased by giving a sufficient radius to the wheels; and the same thing should be done in all cases where it may be found necessary and feasible. Where a more moderate velocity suffices, the force may be increased by any of the usual mechanical means.

Such are the principles on which M. Gloesener proposed, so long ago as 1837, to construct his new motive engine. By means of them, he says, every one who is well acquainted with the electro-magnetic and magneto-electric phenomena will understand the way in which the new motor should be constructed, and could have one made, if he please, by any good mechanician.

The construction, of course, should be carefully supervised; and, so long as the principles be not changed, it would be always permissible to dispose the dimensions, form, and number of electro-magnets, to construct them, and to place them, in the most convenient manner for any particular case.

Those are questions which he leaves to be determined by experiment.

I much regret that space precludes me from following M. Gloesener's most interesting researches further. Should any one desire to do so (and should this be the case the writer of this article will feel himself most amply repaid), let him obtain the "Traité Général des Applications de l'Electricité," which will be found to be a most masterly treatise on almost every branch of electrical science.

I cannot do better than close this paper by a quotation from the biographical notice of M. Gloesener, by François Folie. "I am convinced," he says, "that posterity will ratify the brilliant homage paid him by his illustrious and more fortunate rival, Morse, who regarded 'the magnificent discovery of Gloesener as the natural and proper consequence of those of the immortal Œrsted,' and that the names of his detractors (who can flatter himself that he has had none?) will long have been consigned to oblivion, when his will still be shining with a dazzling light in the field of the applications of electricity."

NOTE ON EARTH CURRENTS.

By W. F. Nosworthy.

In the inaugural address delivered January 28th, 1880, by Mr. W. H. Preece, the following passage occurs:—"Earth currents have been a favourite subject of enquiry of mine for many years. I have always entertained the idea that they are directly due to the action of the sun. Some disturbance in the sun causes, by induction, a variation in the distribution of the lines of potential on the earth's surface, and produces the conditions required for the current."

Since about the middle of 1875, I have devoted much attention to these currents. My observations have been made on a section of the Western and Brazilian Telegraph Company's cables, 338 knots in length, and laid in a direction, more or less, from S.W. to N.E.

From the data obtained, I am led to the conclusion that, although the times at which the current changes in direction during settled weather are regular, the periods of maxima are by no means so; moreover, on such days the strength of current rarely exceeds ·0015 ampères.

A glance at the following table will give a general idea of the results recorded; they are taken from a mass of similar observations:—

Date.	Weather at		Zero.	Max. +	Zero.	Max. —	Zero.	Calculated force of Max. ampères.	
	M.V.	R.G.	H. M.	H. M.	H. M.	H. M.	H. M.	+	—
Nov. 25, 1876	Fine	Fine	a.m. 6 41	a.m. 10 57	a.m. 11 58	p.m. 1 20	p.m. 6 57	·0008	·0007
„ 28, 1876	„	„	6 47	9 30	p.m. 12 20	2 45	6 37	·0012	·0013
Dec. 19, 1876	„	„	6 11	10 20	a.m. 11 48	3 40	6 13	·0009	·0006
„ 23, 1876	„	„	6 15	11 32	p.m. 12 20	2 15	6 14	.0011	·0014
Jan. 9, 1877	„	„	6 34	8 16	a.m. 11 58	4 17	6 17	·0015	·0014
„ 20, 1880	„	„	6 50	10 24	p.m. 12 32	1 32	6 42	·0009	·0007

The days selected for the foregoing table are those on which the weather was fine at both stations, because, during atmospheric

disturbances, at one or both ends, the same regularity is not observed. On such occasions the strength of the current is often equal to ·0040 ampères, but varies in force and direction most capriciously.

In the early part of 1880 my attention was called to what appears to be a direct local influence of the sun on the earth current. On January 25th it was noticed that, while some clouds (cumulus) were passing before the sun, the current varied in strength, apparently in proportion to the density of the passing clouds.

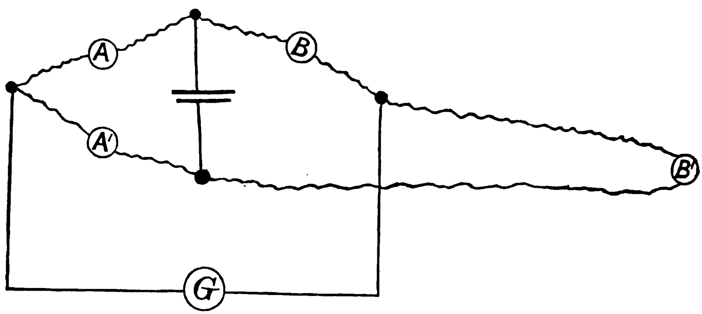
On January 26th I find the following note:—

Date.	Time. H. M.	Remarks on Weather.	E.C. +	E.C. —
1880. Jan. 26	a.m. 8 0	bright and clear sky	60 divs.	...
„	9 35	Wind increasing	35 „	...
„	9 40	A few light clouds approaching sun	37 „	...
„	9 50	Do. do. do.	35 „	...
„	10 0	Clouds passing sun. E.C., which has been steady at 35 since last entry, now fallen to	10 „	...
„	10 15 to 11 15	E.C. varying from 35 + to 10 + Variations apparently connected with intermittent obscuration of sun by passing clouds	35 „ to 10 „	...
„	11 35	Sky clear; clouds passed to N.E...	37 „	...

Again, and as a specimen of several others, I quote the following:

Date.	Time. H. M.	Remarks on Weather.	E.C. +	E.C. —
1880. March 3	a.m. 8 0 to 10 0	Clouds floating about at a great height. E.C. strong and variable, ranging from +45 to 0	44 divs. to 0	...
„	10 20	Sun obscured by clouds	0	...
„	10 21	„ „ „	...	10 divs.
„	10 22	„ „ „	...	20 „
„	10 25	„ „ „	...	30 „
„	10 27	„ „ „ but clearing	...	15 „
„	10 29	„ „ „ much lighter	...	10 „
„	10 35	Sun shining. Direction of E.C. now reversed	20 divs.	...
„	10 40	Sun very powerful	90 „	...
„	11 42	„ „ „ E.C. varying from	20 to 25 „	...

To continue these observations, it became necessary to arrange for simultaneous observations of the sun and earth current. To effect this, my attention was first directed to the thermopile, but on consideration it became evident that this instrument would be unsuitable, for the sun, pouring down its burning rays as it does in these latitudes, would quickly heat the whole of the metal framework of the pile to such an extent as to destroy that difference of temperature between its two faces, on which the current entirely depends. After various experiments in other directions, all of which were more or less failures, I finally had recourse to an electric thermoscope, the arrangement of which will be gathered from the diagram:—



Four coils, A, A', B, B', composed of No. 40 silk-covered copper wire, each having a resistance (finely balanced) of 15 B.A. units, and a diameter of 1·5 inches, were joined up, with a delicate mirror galvanometer and 1 constant Daniell's cell, as a bridge with four equal arms. Three of the coils, A, A', and B, were placed in the office, the fourth (B') was deposited on the roof in such a position as to be fully exposed to the direct rays of the sun, and allow the air free access on all sides, while shielded as much as possible from draughts. This arrangement was eminently satisfactory, clearly and promptly indicating every increment and decrement in the temperature of the sun's rays; a cloud passing before the sun causing a fall on the galvanometer deflection, great

or small in proportion to the density of the cloud and the time occupied in its passage.

The following is the record of the first trial made with this arrangement, and will serve to indicate its sensitiveness:—

Time. H. M. S.	Coil exposed to sun at 2.15 p.m.	Gal. Defln.	Time. H. M. S.	Sun's rays cut off from coil at 2.20 p.m.	Gal. Defln.
2 15 0	... ...	0	2 20 0	... ...	240
2 15 15	After 15 seconds	69	2 20 15	After 15 seconds	205
2 15 30	„ 30 „	140	2 20 30	„ 30 „	180
2 16 0	„ 1 minute	214	2 21 0	„ 1 minute	135
2 17 0	„ 2 „	237	2 22 0	„ 2 „	90
2 18 0	„ 3 „	239	2 23 0	„ 3 „	72
2 19 0	„ 4 „	240	2 24 0	„ 4 „	60
2 20 0	„ 5 „	240	2 25 0	„ 5 „	50

Galvanometer unshunted. Battery, 1 Daniell cell.

It only remained now to throw the spot of light from the bridge galvanometer under or above that of the mirror on which the earth currents were to be observed, in order that the indications of the two instruments might be compared at a glance.

This being accomplished, it was found that such positive results as those previously recorded were not always obtained; further observations indicating that, in addition to the want of uniformity in the weather at the two stations, wind, some clouds, especially cumulo-stratus and nimbus, the amount of aqueous vapour in the atmosphere, etc., all influence more or less the direction and strength of the earth current.

By selecting days of serene weather, with a minimum of atmospheric humidity, these disturbances have been as far as possible eliminated, and some fairly satisfactory results obtained, the most conclusive of which are embodied in the following table:

Date.	Time. H. M.	Deflection of Bridge Galvr.	Deflection of E.C. Galvr.	Calculated Current. Ampères.	Observations.
1880. Aug. 22	a.m. 10 40	Right. 24	Right. 24 +	...	Sun shining.
"	10 42	38	28 +	...	"
"	10 45	44	32 +	...	"
"	11 0	85	56 +	...	" very powerful.
"	11 11	82	63 +	·0003	" "
"	11·19	54	28 +	...	" not so bright.
"	11 21	64	29 +	...	" "
"	11 24	40	24 +	...	Light clouds passing sun.
"	11 27	34	21 +	...	" "
"	11 32	64	29 +	...	Sun shining.
"	11 34	72	29 +	...	"
"	11 35	86	49 +	...	"
"	11 42	90	61 +	...	"
"	p.m. 2 20	Left. 33*	Left. 20 —	...	Sun obscured by clouds.
"	2 35	20	24 —	...	" "
"	2 40	14	32 —	...	" "
"	2 45	17	26 —	...	Sun shining, wind rising.
"	3 0	19	32 —	...	Wind high, sun shining.
"	3 20	24	30 —	...	" "
"	3 50	19	41 —	·0002	" "
"	4 0	27	11 —	...	" "
Sept. 19	a.m. 11 0	Right. 18	Right. 18 +	...	Sun shining.
"	11 10	24	40 +	...	"
"	11 20	26	40 +	·0002	"
"	11 30	21	36 +	...	"
"	11 40	20	30 +	...	"
"	11 50	14	23 +	...	"
"	12 0	19	24 +	...	"
"	p.m 12 10	27	13 +	...	"
"	1 30	29	Left. 38 —	...	"
"	1 40	29	39 —	...	"
"	1 50	34	31 —	...	"
"	2 0	39	24 —	...	"
"	2 10	41	23 —	...	"

* Direction of current reversed in Bridge arrangement.

Date.	Time. H. M.	Deflection of Bridge Galvr.	Deflection of E.O. Galvr.	Calculated Current. Ampères.	Observations.
1880.	a.m.	Right.	Right.		
Sept. 19	2 20	30	36 —	...	Light clouds passing sun.
„	2 30	21	54 —	...	„ „
„	2 40	17	60 —	·0008	Clouds passing sun.
„	2 50	17	58 —	...	„ „
„	3 10	80	4 —	...	Sun very powerful.
„	3 20	81	9 —	...	„ „
„	3 30	56	17 —	...	„ „
„	3 40	76	7 —	...	„ „
„	3 50	42	20 —	...	Sun shining, light breeze.
„	4 0	40	20 —	...	„ „ „
	a.m.	Right.	Right.		
Dec. 12	11 0	21	12 +	...	Clouds passing sun.
„	11 10	17	9 +	...	„ „
„	11 20	24	2 +	...	„ „
„	11 30	54	27 +	·00025	Sun shining.
„	11 40	60	24 +	...	„
„	11 50	54	26 +	...	„
„	12 0	50	20 +	...	„
	p.m.		Left.		
„	1 30	74	39 —	...	„
„	1 40	60	41 —	...	„
„	1 50	40	62 —	·00058	Less brilliant. Light cloud passing sun.
„	2 0	44	40 —	...	Sun shining.
„	2 10	60	54 —	...	„
„	2 20	64	51 —	...	„
„	2 30	57	50 —	...	„
„	2 40	43	21 —	...	„
„	2 50	49	24 —	...	„
„	3 8	52	48 —	...	„
„	3 10	52	17 —	...	„
„	3 20	49	29 —	...	„
„	3 30	56	22 —	...	„
„	3 40	61	31 —	...	„
„	4 0	44	61 —	·00056	„

It is perhaps worthy of remark, that the days on which the above and similar results were obtained, are, without exception, those on which the earth currents were unusually small. The

fifth column gives the strength of the maximum current, in ampères, on the 22nd August, 19th September, and 12th December respectively.

The two spots show considerable variations, as, for instance, between 11 a.m. and 2.10 p.m. on September 19th, without any visible cause. It is certain, however, that the coil received a variable amount of heat; and although no clouds were passing at the time to intercept the sun's rays, yet it is possible that the heated air rising from various tropical regions, containing aqueous vapour in vastly different proportions, on being carried past the coil by the higher atmosphere currents, absorbs a greater or less quantity of heat, in proportion to the water held in suspension.

There is, of course, no proportion between the deflections of the two mirrors, nor, indeed, was any anticipated; nevertheless, the tables show clearly that the movements of the two spots are nearly always in the same direction, and that the cloud, or aqueous vapour, which intercepts the heat of the sun's rays, also modifies that energy which appears to be the origin of those currents so well known to all engaged in telegraphy. But whether the earth currents are due to "inductive action caused by disturbances in the sun," or simply to heat, remains a problem yet to be solved. To me, however, it seems difficult to arrive at any other conclusion than that the two galvanometers were influenced by energy derived from the same source, that source being the sun.

I am at present, for various reasons, unable to continue my enquiries, but trust at a future date to be able to resume them in connection with observations on atmospheric pressure, force and direction of wind, humidity of the atmosphere, and other meteorological effects, all of which doubtless play a very important part in modifying the distribution of the lines of electrical potential on the earth's surface.

MONTE VIDEO, *April*, 1882.

SOME REMARKS ON THE TECHNICAL EDUCATION OF AN ELECTRICAL ENGINEER.

By Professors W. E. AYRTON, F.R.S., and JOHN PERRY, M.E.

In the able inaugural address given us this year by our President, Lieut.-Colonel Webber, R.E., reference is made to the difficulty of defining what ought to constitute the education of an electrical engineer, so wide and varied are the duties he has to perform.

Now, as the majority of the readers of this Journal are interested in the education of this class of engineer, it may be well to consider shortly what are the branches of education to which a student desirous of entering the profession ought to apply himself.

First and foremost, one sees the necessity for a union of mechanical and electrical knowledge in the training of this new kind of engineer. There exist numerous mechanical engineers with a wide knowledge of mechanical principles, but with no acquaintance with the laws of electricity; on the other hand, there are many electricians well versed in the solution of problems regarding the flow of electric currents, and in similar electrical questions, but with little or no knowledge of the strength of materials and of structures, or of the laws of machinery.

Now, neither of these men, by himself, is of much use to a company engaged in electric lighting or in electrical transmission of power; neither, in fact, by himself, can do the work of an electrical engineer. Hence a new kind of profession has with the force of circumstances created itself, the members of which who are really skilled form as yet only quite a little band; and the smallness of this band does not arise from the absence of demand for followers, but from the paucity of supply arising from the peculiar combination of acquirements necessary for success in the electrical engineering profession.

First, the student must know something of mechanics and of mathematics; and by this we do not mean that he must be deeply versed in mathematical gymnastics, such as a senior wrangler is supposed to be a proficient in, but that, when he has a practical

problem to solve, his attention may be devoted to the physical part of the question, without his mind being unnecessarily harassed by the x's and y's that necessarily are present in all work of the present day.

Lads are, as a rule, disgusted with mathematics, and the reason is that they are wrongly taught. Too much use is made of mathematics as a training of the mind, and too little attention is given to its practical utility. The method commonly employed for teaching young people mathematics is not unlike that of teaching a boy the motions of the arms and legs employed in swimming before he has ever seen the water, or gathered that there can be any use in swimming.

If you plant an English lad in Germany and leave him there, he learns German ; if you plant him in Russia, he learns Russian ; but if you give him a dictionary and a grammar, and send him in England to a public school, the chances are he does not learn the foreign language. In the one case he sees the immediate value to him of the foreign language, in the other case he does not even see the remotest advantage.

And so in the same way, instead of allowing our lads to sit brooding by the hour together over a proposition in Euclid, hardening their hearts and dulling their understandings by following a process which we call mental training, we ought to commence more in the middle of the subject of geometry, teaching students to test by actual experiment the truth of many of Euclid's propositions. We should give them a real interest in what they work at, by commencing early the study of physics, so that their observational and reasoning faculties may be more rapidly developed than they possibly can be when we begin with abstract truths and a series of enigmas like extracts from the Shorter Catechism of the Presbyterian Church.

And what is true of lads is still more true of men whose lives have hitherto been spent in practical life. It is through the practical value of mathematics that a knowledge of it must come ; and any teacher who refuses to consider the instinctive preference of his pupils to reason about *things* rather than about *ideas*, is a man who persistently refuses the powerful aid of nature.

We are frequently consulted by anxious parents as to the best course of training that should be pursued by their sons at school, whom they have destined to become electrical engineers. Our first question invariably is, Has your son been learning physics at the school he is at? and, if so, has he ever made any experiments himself, or at any rate does he see experiments made by the lecturer at the lectures? We regret to say that, although the lad is at what the world would call a good school, the answer frequently is that he is merely learning physics out of books by rote; not only not testing himself by experiment what he reads, but never even seeing the result tested for him. Indeed, it frequently happens that even non-quantitative or illustrative experiments have never been seen by him.

Our advice in all such cases is, Let your son commence his technical education at once, for he will learn more pure science in the intervals of rest during his technical education than he will ever acquire if he devotes himself exclusively to a book-work education.

During the last year or two much has been heard about this subject of technical education, and the question must frequently have arisen: How does this technical education differ from school education? or else, How does it differ from mere workshop training?

By a technical college, we understand, not one in which a training is given in handicraft, but one in which a general education in the application of science to industry is given to all the students, and a special education in the application of science to special industries is given to individual students, one large class of which, the students of electrical engineering, interest us to-night.

We have spoken of the importance of such students learning mathematics and mechanics—next, a knowledge of machine drawing and designing is essential. But in a modern science like electrical engineering, it is most important that the newest forms of instruments should be constantly put before the students to draw, since it is highly desirable, not only to cultivate the student's power to use existing knowledge, but also to cultivate his originating power, if he possesses any.

Great care must therefore be exercised that the drawings do

not, from being repeatedly made by different students in succession, become a sort of stereotyped performance, the actual machine drawn having well-nigh passed out of date, and only existing on the students' drawing boards.

It might at first sight appear to be imposing too great a tax on the instructors to ask that new designs should be given to the students each year of the college course; but although this may be the case in mechanical and civil engineering, in electrical engineering it presents less difficulty, for there is so much yet to be done in the subject, and there are so few men who are able to do it, that the instructor, if he be the proper man, will only be too glad to obtain the assistance of the students in carrying out new and original ideas and investigations.

Electrical engineering has, in fact, a great advantage over its sister branches, in that the students can always be engaged in real living work, and need not merely confine themselves to designs, for the carrying out of which there is no opportunity. But although it is perhaps more difficult in mechanical and civil engineering for the students year after year to receive a constant succession of new work to carry out, this difficulty even is much diminished if the teachers are actually engaged in the practice of the profession they are teaching; indeed, it is only by practising one's profession that it is possible to keep abreast of the advances that are being daily made.

This year, at the request of the City and Guilds of London Institute for the Advancement of Technical Education, one of us visited, with our colleague Dr. Armstrong, and with Mr. Robins, a member of the executive committee, the Universities and Polytechnic Institutions of Geneva, Zurich, Munich, Vienna, Dresden, Chemnitz, and Wurtzburg.

At the Zurich Polytechnic we saw the physical laboratory of Weber; at Munich, Beetz showed us his splendid collection of physical and electrical apparatus in his various working rooms in the Polytechnic, and Jolly his useful, but less elaborate, collection at the University; Reitlinger and Pièrre at the Polytechnic at Vienna, and Stephan and Von Lang at the University, explained everything to us in detail; at the New Polytechnic at Dresden

we saw the many ingenious contrivances carried out in the large laboratories there, and which were described to us by their designer Toepler; Weinhold, whose new book on physical laboratory fittings is well worth careful study, showed us at Chemnitz how he had carried all his ideas into practice; and lastly, at Wurtzburg, Kolrausch in the physical laboratory, which is a large building standing distinct from the university, exhibited the classical electrical apparatus of his father, and showed into what it had grown in the carrying out of his own more recent electrical researches.

We also saw the many chemical laboratories at the various polytechnics and universities.

In addition to the professors of pure physics and of pure chemistry at the universities, there are generally also professors of pure physics and of pure chemistry at the polytechnics, in addition to the professors of technical physics and of technical chemistry at these more technical institutions—for example, Reitlinger is the professor of technical physics, and Pièrre that of pure physics, at the Vienna Polytechnic. The difference between the laboratories or between the two modes of teaching of the professors of pure and of applied physics is not easily distinguishable; indeed, the chief noticeable difference in the two departments is that the students under the technical professor are intended to become teachers, but not teachers of technology in our sense of the word. It appeared to us to be a great fault that the technical instructors at the polytechnics were simply distinguished physicists, but were not themselves engaged in the practice of their professions, and consequently that the students were not engaged in designs that were to be carried out in practice. And this want of connection between the real to-day life of an engineer and the comparatively stereotyped polytechnic training was so marked, that at no one of these polytechnics was there any provision made for educating electrical engineers. At the Vienna Polytechnic, for example, they had at one time thought of establishing classes in telegraphy, but had never carried out the idea; while the courses in the same subjects at the Dresden Polytechnic had, we understood, collapsed on the departure of Dr. Zetzsche to Berlin, to take charge of the *Elektrotechnische Zeitschrift*.

In many of the physical laboratories, dynamo machines existed, but they were used merely for producing the electric light for projection at the lectures, and no arrangements whatever were visible for experimenting on these dynamos to ascertain their efficiency, or to see what commercial improvements could be made on them. In some of the laboratories of the professors of applied physics, measurements of the magnetic moments of magnets were being made, and similar experiments were being conducted by the students, but such experiments did not differ from the kind that are made in the physical laboratory of any university, and had nothing technical about them. They were not of the nature to appeal at once to an electrical instrument-maker as something that necessarily interested him and affected his business. In short, the professors of technical physics were not technical; they differed from the professors of physics at the universities in little more than the name.

Again, the want of real vitality was shown by the fact that the students of architecture who had passed through the Polytechnic of Dresden frequently could not find employment, while those who had passed through the less elaborate course at the "work school" in the manufacturing town of Chemnitz, close by, found no difficulty in this respect.

Objections at various times have been raised to both the French and the German systems of technical education, in that in the one country the subject is taught as if the whole subject were complete and no further advance could be made, while in the other there is such a perpetual search after change that the student has no settled ideas. Both these defects are, we think, met if the teacher is a scientific man professionally engaged in the practice of the profession he is teaching the technology of. Being an original experimenter himself, the students will soon see that at any rate he does not regard all scientific knowledge as complete, while on the other hand his commercial practice will make him attend to experiments that have an immediate, or at any rate a distant, practical value, and will prevent his blindly experimenting, merely to try something new.

Next to machine designing and drawing, comes, in the

education of an electrical engineer, a practical knowledge of electricity, and by this, of course, we mean something far more exact than an acquaintance with the effects of rubbing cats' backs and standing on glass-legged stools.

A knowledge of electricity, like any other knowledge, to be of any real value, must be, first, experimental, and next, quantitative, not merely qualitative. Nobody ever learnt electricity from a book, any more than that any person ever acquired the art of swimming or bicycling sitting in an arm-chair.

During the Crystal Palace Electrical Exhibition, when we have been gazing with wondrous admiration at those Eastern courts, looking more beautiful with their tracery of incandescent lamps than anything we have ever seen in a voyage round the world, we have been frequently asked by persons not professionally connected with electricity, but whose very souls were stirred with a peep into the world of the Arabian Nights, the question, "Now, what book would you recommend me to read in order to know all about electricity? You know I have not got much spare time, but I suppose I could pick it all up in my leisure." And what answer could one make? One told them that if they only wanted to know a mere something of the electric light, any popular book, any course of popular lectures, would answer the purpose. But if they really wanted to dive deep into the subject—if they desired to understand why one dynamo machine was more efficient than another—why one system of electric lighting, although so brilliant and loudly praised, was really far inferior to another with much less pretensions, then that they must be prepared to enter on a course of professional education like that of reading for the bar or walking the hospitals. And this professional education must be an experimental one. The student must not be satisfied by reading that so and so is the case—he must try it experimentally for himself, if he is ever to grasp the subject. And further, he must not only find out for himself that such and such a result is produced by such and such a cause, but he must ascertain the magnitude of the result in connection with the magnitude of the cause.

This laboratory work must be directed by means of the

lectures, instead, as is too frequently the case in colleges, the physical laboratory work being regarded as a sort of fashionable supplement to the lectures. And in the laboratory, as soon as the students have all carried out a series of well-arranged quantitative experiments, they ought to take in hand an investigation which has for its object, not merely the cultivation of their minds, but also the advancement of actual knowledge—the solution, in fact, of some problem which the instructor has set himself to solve.

It will doubtless be objected that to find such instructors must be a difficult task. But unless they be found (and it is possible, for there are a few such men), and unless sufficient funds be available to retain the services of such qualified electrical engineers, it will not be electrical engineering that will be taught, but merely simple electricity, instruction in which can already be obtained at every college in the country; but which instruction alone, as we have already explained, does not fit a man to become an electrical engineer.

We think we have said sufficient to show the importance of any college which lays itself out for imparting a systematic training in electricity. Such is one of the objects of the new college at Finsbury, now almost finished, and which has been erected by our much abused City Companies, who have, in a most praiseworthy manner, formed themselves into an institute for the advancement of technical education—for giving, in fact, technical education at a merely nominal cost to the student.

For the last two years such an education has been given, in a more or less hand-to-mouth fashion, in some small temporary rooms rented in Cowper Street from the Middle Class Schools Corporation. The education has necessarily been fragmentary, from the absence of space, and especially from the absence of a sufficiently large teaching staff; but we venture to think that the men attending the laboratory courses have been able to gain much information of professional value to them. And we are led to this conclusion, not because we have had well-polished cabinets full of highly-lacquered instruments, but because some hundreds of men, after their day's work in electric light factories or instrument makers' workshops was over, have thought it worth while to come regularly, night after

night, to learn how the efficiency of an electric lamp or of a dynamo is actually measured—how to obtain, experimentally, the characteristic curves of dynamo machines at different speeds, or to engage in the smaller experiments of calibrating galvanometers, testing magnets, etc. In addition to the laboratory practice, which forms the most important part of the evening's work, lectures are given, but the lectures are more for the purpose of directing the student's laboratory work than for enabling students to dispense with it.

The experiments in the laboratory are all quantitative, and one speciality consists in the laboratory containing a large number of experiments always ready, and each complete in itself, which the students, in groups of three, perform *seriatim*. In a chemical laboratory a student may have a bench assigned to him, and the greater part of the apparatus necessary to enable him to go through a course of experiments can be brought to him. Also a large number of students may at the same time each be performing the same experiments with different sets of apparatus. In a physical laboratory, on the other hand, a very different course must be pursued: the student must go to the experiments instead of the experiments being brought to him, since the apparatus generally requires adjusting and fixing in position, so that far too much time would be wasted, unless each student could avail himself of apparatus already adjusted. But something more than this is necessary. If a large number of students be working at the same time in a physical laboratory—an electrical one, for example —it is useless making one galvanometer or one set of resistance coils do duty at different times for half a dozen different experiments. Whatever is necessary for any one experiment—galvanometer, key, battery, resistance coils, etc.—must be ready and in its place for each group of students to use it in turn. Of course such a system requires a considerable quantity of apparatus for the more important fundamental quantitative experiments that every student ought to perform as part of his electrical education.

Students must be early taught to graphically express the results of their work on squared paper; indeed, it is wonderful what an insight into analytical geometry even a non-mathematical student

can obtain from a judicious use of squared paper. Hence it has been necessary to have prepared for the students at the Finsbury Technical College a special form of squared paper, for drawing curves on, which combines accuracy with about the sixth of the price of ordinary squared paper such as is used by engineers.

All the experiments being quantitative, and not merely qualitative, the results can be all graphically recorded, and the students are from the beginning taught to map out the results of each experiment.

As soon as a student has gone through the organised series of experiments, he is (if he does not get drafted off into an electrical company, which, unfortunately for his future education, but fortunately for his pocket in the immediate present, is but too often the case,) set to carry out a series of what may be called scientific commercial experiments—that is, the kind of experiments an intelligent electrical engineer would carry out in his own factory to enable him, by applying the laws of science to his industry, to obtain the best practical results with the least expenditure of money. And the various measuring instruments used in electric lighting and transmission of power, described in another paper in this number of the Journal, form one part of the outcome of the joint work of the students and ourselves in this direction; the various recent investigations made by the students on dynamo machines, electric lamps, and electric transmission of power, form another.

In the new building, which will probably be opened this autumn, there will be, we trust, sufficient apparatus, material, and assistants to enable large numbers of students to work in the laboratories at the same time, so that it is to be hoped that all those who wish to gain a practical knowledge of electrical engineering, and who have not the means to pay large fees, will avail themselves of the liberality shown by the City and Guilds of London Institute in establishing the Finsbury Technical College.

ABSTRACTS.

TRANSMISSION OF POWER TO A GREAT DISTANCE.

("L'Electricien," V. 2, No. 24, 1 Avril, 1882, pp. 592-594.)

The author, who signs with the initials "E. H," criticises the results of M. M. Levy, and shows that they cannot hold in practice. He takes as example the problem of transmitting 50 horse-power a distance of 100 kilomètres with a loss of only 20%, which is the same as that considered by M. Levy.

The present large Gramme machines, capable of supplying 10 lamps on one circuit, have an E.M.F. of not more than 600 to 700 volts; but in the present case the author supposes that a machine with an E.M.F. of 1,000 volts is used. The strength of the current traversing the conductor will be

$$I = \frac{9{\cdot}81 \times T}{E} = 37{\cdot}5 \text{ ampères.}$$

The loss due to heating of the wires ought not to exceed 20% of the work expended—in this case 10-horse power, or 750 kilogrammètres per second. The resistance of the conductor will be

$$R = \frac{H \times 9{\cdot}81}{I^2} = 5{\cdot}3 \text{ ohms.}$$

What, then, will be the section, the diameter, the weight, and the price of a copper conductor 100 kilomètres long, having a resistance of 5·3 ohms?

The specific resistance of pure copper—*i.e.*, the resistance between two opposite faces of a cube of copper one centimètre each way—is 1·642 microhms, whence the resistance of a pure copper wire one square centimètre in section and 100 kilomètres long will be 16·42 ohms. To reduce this resistance to 5·3 ohms, the section of the conductor must be 3·1 square centimètres. This conductor would contain 31 cubic mètres of copper, and would weigh 279,000 kilogrammes (274·5 tons). At 3 francs the kilo., the conductor alone, without insulation or labour, etc., for installation, would cost 837,000 francs (£33,480). As the useful work would at most amount to 40 horse-power, this represents £800 per horse-power, equivalent to £40 per annum as interest—that is, the capital expended on the conductor alone would represent a larger sum of money than the direct production of the work by an engine of 40 horse-power.

The above calculation is on the supposition that the earth is used as return; but if a return wire were required, the quantity of copper used would be four times as great, and the capital expended would represent an interest of £160 per annum per horse-power.

The author concludes that, with the present types of Gramme machines, and with an E.M.F. of not more than 1,000 volts, it is impossible to transmit economically a force of 50 horse-power to a distance of 100 kilomètres, on the condition that 80% is utilised at the further end.

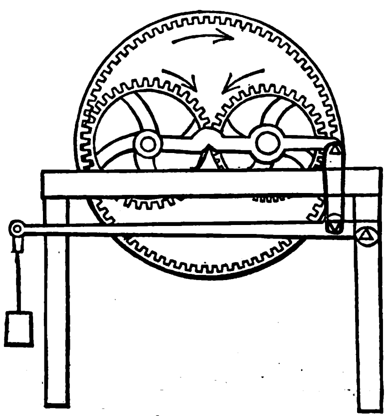
M. Sarcia, experimenting with two Gramme machines, was able to transmit two horse-power through 3 kilomètres of copper wire 4 mm. in diameter with an expenditure of 4 horse-power. Arguing from his experiments, M. Sarcia calculates that in M. Levy's example the conductor would have to be 115·5 mm. in diameter, would weigh about 9,350 tons, and would cost about £1,250,000, or £12,000 per horse-power.

M. J. RAFFARD—TRANSMISSION DYNAMOMETER.

(*"L'Electricien," V.* 3, *No.* 25, 15 *Avril*, 1882, *pp.* 5-8.)

The shaft from which the power is derived is connected by a universal joint to the axle of a wheel revolving in bearings fixed rigidly to the base plate of the dynamometer. This first toothed wheel engages with a second which is slightly larger, revolving in a cylindrical bearing in the end of a lever. The second toothed wheel gears into the teeth on the inside of a third wheel, large enough to enclose both the former, which is connected by a belt to the machine to be driven. Since the work is equal to the product of the force transmitted and the space passed through by the point of application of the force, we have to measure the thrust of the second wheel on to the third at the point where they gear into each other, and the linear velocity of this point.

The fulcrum of the lever is exactly midway between its extremity, where the weight is applied, and the point of contact of the second and third wheels, and therefore the force can be measured at this extremity. This is effected by connecting the first lever to a second, the arms of which are in the ratio of 1 : 10 The following is a rough sketch of the arrangement:—



It is to be remarked that the first two wheels gear into each other exactly at the point where the fulcrum of the lever is placed, and consequently the action of one of these wheels on the other does not affect the lever.

With regard to the space traversed, by giving to the exterior wheel a

diameter such that its circumference is just 3 mètres, and by counting the number of revolutions (n) it makes per minute, $3n$ will be the space passed through per minute. Hence the work in kilogrammètres per second will be

$$T = \frac{10 \, P \, 3 \, n}{60} = \frac{P \, n}{2}$$

where P is the weight suspended at the end of the second lever.

This dynamometer gives exactly the measure of the work sought, since the friction of the exterior wheel is alone included in the work to be measured.

M. N. DE KABATH—SECONDARY BATTERIES WITH CORRUGATED PLATES.

("*L'Electricien*," *V.* 3, *No.* 26, 1 *Mai*, 1882, *pp.* 79-83.)

These, like all other accumulators, are only practical developments of M. Planté's original secondary battery, and their construction has been rendered necessary in order to obtain the maximum of surface with a minimum of material. M. Faure sought to increase the containing power of his batteries, not by increasing the active surface, but by increasing the thickness of the active body by applying a layer of oxide of lead on each side of his lead plates. This, M. Kabath considers, did not have the desired effect so far as the capacity of the batteries was concerned, though it considerably lessened the time necessary to form the plates. As M. Faure has said himself, in a letter to M. Hospitalier:—

"I have paid great attention to the electro-chemical theory of my battery, and by repeated analyses of the substance of the active layers of the electrodes at different times of the charge and discharge, always allowing for the current which had passed between two experiments, I believe that I have been able to make out that the effect which is first observed is the carrying of a certain amount of oxygen from one plate to the other, and *vice versâ*, in accordance with the electro-chemical equivalents; and that, for example, during the discharge, the reduced lead was converted into $Pb_2 \, O$, whilst the $Pb_2 \, O_4$ was changed into $Pb_2 \, O_3$. But I have remarked that this only took place in a small proportion to the total thickness of the layers, about 10 per cent. I attribute this to the resistance opposed by a semisolid substance, such as the oxides of lead, to the transmission of the electrolytic action; in fact, a considerable portion of the mass is unacted upon."

In the form of accumulator described, each box contains a dozen or more plates of lead, each plate being built up of a series of strips of lead $\frac{1}{10}$ mm. thick and of a suitable length, the slips being alternately flat and corrugated, and arranged side by side to the number of 80 or 100. The strips are held together by a flat plate of lead, which is wrapped round them, and which is pierced with a quantity of holes to allow of a free circulation of the liquid. The accumulators are made either upright or flat; in the large upright form the plates are about 40 cm. high and 8·5 cm. wide by 1 cm. thick. The accumulator with its box weighs about 30 kilos., and the charge of acidulated water ($\frac{1}{10}$) about 5 kilos. more. The whole is placed in a lead-lined wooden box, provided with two handles. The flat form has only 10 plates, and weighs 25 kilos.; it is not so easily moved, but is less liable to be upset.

MASSMANN—DAMAGE CAUSED BY BIRDS TO TELEGRAPH LINES.

(*Electrotechnische Zeitschrift, V.* 3, *H.* 1, *January*, 1882, *pp.* 5-7.)

The following interesting remarks upon the damage caused by birds to telegraph lines in Germany were recently submitted to the Electrotechnic Society by Herr Massmann. He said that, at the instance of the Secretary of the Imperial Post Office, enquiry had been made during the past summer into the extent of the damage birds cause to overground wires. Through this enquiry some interesting facts have been brought to our knowledge, which I will here briefly mention. In districts where there are no trees, the smaller birds of prey, such as crows and magpies, are very fond of roosting on the telegraph poles; and starlings, swallows, and sparrows not unfrequently alight in great numbers on the wires. On those occasions the wires are soiled by the excrement of the birds, and indeed often look as if they were whitewashed. This has, however, no damaging influence, as the first shower of rain clears the wires of the dirt. It is very probable that the acid excrement of the birds imparts to the wood a tendency to decay.

Swallows and sparrows like to build their nests under projecting roofs where the wires are led into the telegraph offices, and on the pillars through which the overground wires are connected with those underground. The nests can easily cause contacts between the wires. But far worse are the interruptions caused by birds flying against the wires. When the larger birds, such as bustards, storks, swans, and wild ducks, thus come into contact with the wires, they may possibly cause several wires to swing, and thus become entangled, or they may cause the wires to be broken. Formerly, when the wires were more frequently erected along the high roads than at present, such interruptions occurred very often, and especially at certain times and places when the young geese were driven in the morning to the pastures, and home in the evening. On such occasions the goslings will often fly against the wires, especially when there is a dark background behind the latter.

Smaller birds, even partridges, are generally killed by the shock when they come into contact with the wires in full flight. Very often numbers of small birds are found to have met their death in that way.

At some places where there are many wires, as in the case of the railways, the line-keepers are said to derive some income from that source. Generally speaking, the smaller birds do not cause any serious damage. Their weight is not considerable; even when they do alight in great numbers, the wires will not sag much, neither will they swing to such an extent as to cause contacts, even if all the birds that were perched on them took to flight simultaneously. Yet some cases of contact caused in that way are on record, but they are rare, and may be counted as exceptions.

Of more interest is the damage caused to the poles by woodpeckers in their search for food. Holes have been found hacked in the poles by those birds, penetrating to the centre, and in some cases through the poles. The holes are conical, and have a diameter at the outside of the poles of 6 to 12 cm., and some-

times more. The crevices caused by the heat from the rays of the sun are often considerably enlarged by those birds.

Of the different kinds of woodpeckers, the *picus martius* (the black woodpecker), the *picus viridis* (the green woodpecker), and especially the *picus major* (the piebald woodpecker), have been observed attacking the poles. In the well-wooded district where the woodpeckers abound, similar damage is principally met with. The woodpeckers spare no kind of wood—unprepared pine and oak poles, as well as poles treated with sulphate of copper, chloride of zinc, or sublimate mercury. It has even been proved that they attack creosoted poles, which had been doubted by several competent authorities.

It has been asserted that the woodpeckers are attracted by the humming noise of the telegraph wires, thinking that that noise is produced by insects; but we can with equal right assume that those birds have sense enough to distinguish between the humming of the wires and that of insects. The fact of the matter is, that the birds expect to find, and do find in abundance; insects in the dry telegraph poles.

In conclusion, the speaker showed a few very interesting specimens, consisting of sections of poles on which the damage done by the woodpeckers was plainly visible.

O. FRÖLICH—THEORY OF DYNAMO-ELECTRIC MACHINES AND THE TRANSMISSION OF POWER.

(*Elektrotechnische Zeitschrift, V.* 3, *H.* 2, *Feb.* 1882, *pp.* 69-73, *and V.* 3, *H.* 3, *March,* 1882, *pp.* 113-117.)

These articles are a reply to M. Marcel Deprez, who has been writing on the same subject in "La Lumière Electrique," and are a continuation and amplification of a former article which has been abstracted in the Journal of the Society, V. 10, No. 37, p. 281.

The E.M.F. of a dynamo machine is proportional to the number of convolutions on the armature (n), to its speed (v), and to the magnetic forces acting on the armature, or "effective magnetism" (M), and for such a machine Ohm's law will take the form

$$I = \frac{n\,M\,v}{R}\,; \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (1)$$

but since the effective magnetism depends on the strength of the current, we have really this equation—

$$I = F\left(n\,\frac{v}{R}\right), \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (2)$$

and n being constant for the same machine,

$$I = n\,F\left(\frac{v}{R}\right)$$

—*i.e.,* the strength of the current depends only on the ratio of the speed to the resistance. In order to determine in what way I depends on $\frac{v}{R}$, it is only necessary to measure the current when the machine is running at various speeds, and with various resistances in the circuit. If, then, the values of $n\,\frac{v}{R}$

are calculated and marked off as abscissæ, the values of I as ordinates, a curve can be constructed which represents the function.

The quantities sought for with respect to any machine are the strength of the current, the E.F.M., the effective magnetism, the speed, and the resistance; and if any two of the three, I, v, or R, be given, the other can be calculated from the curve, and then $E = I R$, $M = \frac{1}{n} \cdot \frac{E}{v}$.

The number of experiments necessary to determine the curve exactly would, however, in practice occupy too much time. A shorter method can be used. In practice the currents are neither very large nor very small, and within these limits the curve differs very little from a straight line, and hence the strength of the current will be a linear function of $n \frac{v}{R}$, or

$$I = \frac{1}{b}\left(n\frac{v}{R} - \frac{1}{a}\right) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

In this equation a is the value of the minimum speed necessary to produce any current at all; b is found from the equation

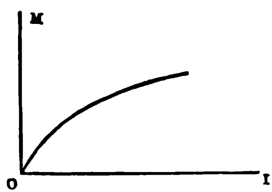
$$b = \frac{n\frac{v}{R} - a}{I}$$

Another meaning may be found for the constants a and b by considering the ratio of the effective magnetism to the current: from (1) and (3), by eliminating

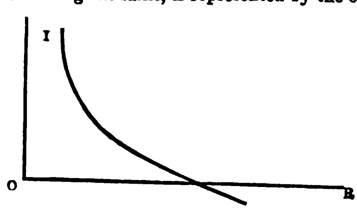
$$\frac{v}{R}, \text{ we get } M = \frac{I}{a + b\,I}, \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

from which we see that $\frac{1}{a}$ is the ratio of the effective magnetism to the current for very weak currents; $\frac{1}{b}$ the value of the effective magnetism for very strong currents—*i.e.*, the maximum of the magnetism.

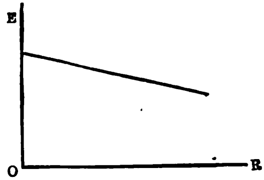
The curve given by equation (4) for Siemens and Gramme machines is of the form



The change in the current strength, due to change in the resistance in the circuit, the speed remaining the same, is represented by the curve



The change in the E.M.F. under the same circumstances is given by the equation $E = \frac{1}{b}(n v - a R)$, which represents a straight line



The chief cause of the magnetism is the magnetising power of the coils on the electro-magnets, by which not only the electro-magnets, but also the armature is magnetised. The armature coils have also an important magnetising power; but their effect is opposed to that of the electro-magnets; when the armature rotates the magnetism is weakened. It has generally been assumed that the magnetism is proportional to the number of convolutions on the electro-magnets; but experiment has shown that the constant a in the above formulæ for the effective magnetism is about proportional to the $\frac{3}{4}$ power of the number of convolutions on the electro-magnets.

On making a comparison between magneto and dynamo machines, we find that in the former the magnetism is $\frac{1}{3}$ to $\frac{1}{4}$ less than in the latter; though, however, the magnetic field of a dynamo machine is stronger, it has to be produced by the current of the machine itself, unless of course an exciter be used. With a dynamo machine, therefore, more power is necessary to produce a given current than would be required to produce the same current with a magneto machine; on the other hand, the dynamo is smaller, cheaper, and of more simple construction.

The author thinks that the curve obtained by M. Deprez from his experiments is not a correct representation of the action of a dynamo machine, because M. Deprez method of experimenting was inexact, as he used a dynamo in a different manner to that obtaining in practice.

He then goes on to consider the question of transmission of power. For practical purposes there are two limits to the use of dynamos—the speed at which they can be driven, and the quantity of heat generated in the coils. But if the maximum speed and the maximum amount of heating are settled, all the other quantities can be deduced. Thus, from the heat the current can be found by the formula $H = I^2 R$, since R is constant for the same machine; from the current we obtain the strength of the magnetic field; from the magnetic field and the speed, the E.M.F.; and from the current and the E.M.F., theoretical work.

The quantities entering into the question of the transmission of power are the following:—

W_G, the work required to drive the generator.

W_m, the work given out by the motor.

H, the heat produced in the armature and magnets.

h, the heat produced in the iron core of the armature.

c E I, the electrical work, where c is a constant.

If there were no loss we should have $W_G = W_m = c\,E\,I$; but actually if only two machines are used, one as generator and the other as motor, we shall have

$$W_G = W_m + h_1 + h_2 + c\,I^2\,R$$

and

$$W_G = c\,E_1\,I + h_1$$

$$W_m = c\,E_2\,I - h_2$$

There are two sources of loss, the heating of the iron core and the heating of the wire coils and leads.

In order to find out the efficiency of any machine, it should be driven either directly or as a motor at the maximum of speed and of heating, and the work and electrical quantities measured, when the above formulæ will serve for the calculations.

Suppose the case of a second machine with p times the number of windings on it that are on the first of wire p times smaller in section, and that the amount of heating of the wire is to be the same, then the current passing through p wires of the second machine must be equal to the current going through one wire of the first, or $I^1 = \frac{1}{p} I$. The strength of the magnetic field will remain the same, for putting the former constant $a = \frac{a}{m}$ where m is the number of convolutions on the magnets we have,

$$M^1 = \frac{I^1}{\frac{a}{p\,m} + b\,I^1} = \frac{\frac{1}{p}\,I}{\frac{1}{p}\frac{a}{m} + \frac{1}{p}\,I} = M.$$

Whence for the E.M.F. follows

$$E^1 = n p \,.\, M^1 v = p \,.\, E,$$

and

$$c\,E^1\,I^1 = c \,.\, p\,E \,.\, \frac{1}{p}\,I = c\,E\,I.$$

The heating of the iron core must be the same as before, since the magnetism and the speed remain the same, and therefore the work absorbed and given out will also be the same. Hence, the speed and the amount of heat being kept the same, the E.M.F. is p times as great, the resistance p^2 times greater, the current p times smaller, magnetism and work the same.

As result of his investigations the author recommends, for a case where the resistance of the leads is not too great, the use of three similar machines, two as generators, coupled in series, and one as motor. If the leading wires are to be small on account of cost, then machines wound with thinner wires should be used; the limit to their use being determined by the insulation necessary for the increased E.M.F.

The author concludes by examining the question of the transmission of power from a central station over a large area, the principles above laid down for a pair of machines being applied to the several groups of machines needed in this case.

BREAKING STRAIN AND CONDUCTIVITY OF PHOSPHOR BRONZE WIRE.

(*Elektrotechnische Zeitschrift, V. 3, H. 3, March,* 1882, *p.* 117.)

The following table contains the experimental results obtained by the German Telegraph Department. The wires were got from two different manufacturers :—

Gauge.	Breaking Load.	Breaking Strain for Section of 1 □ mm.	Resistance of 1 Kilomètre at 18° C.	Resistance of 1 Kilomètre. 1 □ mm. Section at 18° C.
mm.	lbs.	lbs.	ohms.	ohms.
0·70	31·967	83·113	310·390	119·451
0·75	38·581	87·301	223·950	98·933
0·85	49·603	87·523	171·499	97·312
1·20 hard	100·580	88·846	80·220	90·718
1·20 soft	66·138	59·083	82·542	93·348
1·00	85·428	108·69	152·395	119·413
1·20	122·200	108·03	89·696	101·449
1·25	202·440	164·90	60·425	74·154

For the sake of comparison, it may be stated that the cast steel wire used for telephones of 2·2 mm. gauge gives the values

1214·7 lbs., 319·67 lbs., 51·768 ohms, and 196·718 ohms.

The unfavourable results of these experiments have induced the German Telegraph Department to defer for the present any further use of the phosphor bronze wire.

G. WIEDEMANN—METHODS OF DETERMINING THE OHM.

(*Elektrotechnische Zeitschrift, July,* 1882, *V.* 3, *H.* 7, *pp.* 260-269.)

The Congress of Electricians held last year in Paris having accepted the C.G.S. system as the basis of the electro-magnetic units, and having decided on the desirability of a fresh determination of the absolute value of the ohm, the author is of opinion that it will not be without interest to give a *résumé* of the methods which have hitherto been employed for determining the unit of resistance, and to point out the chief sources of error inherent to the several methods.

W. Weber has proposed four methods by means of which the resistance of a conductor may be determined in electro-magnetic measure.

I. A coil of known dimensions is rotated through a certain angle about an axis inclined at a fixed angle to the direction of the vertical component of the earth's magnetism, and the intensity of the current thus produced in the circuit is measured on a galvanometer of known dimensions. Under like

circumstances this intensity is inversely proportional to the resistance of the circuit.

II. Without knowing the dimensions of the galvanometer, the action of the unit current on the needle can be determined by the damping of the oscillations of the needle.

III. The needle is allowed to oscillate in a galvanometer of known dimensions, and the damping of the oscillations is determined.

IV. A circular coil is rotated uniformly about its vertical or horizontal diameter, and the deflection of a needle at its centre, caused by the current induced by the earth's magnetism, is determined.

The author deals first with the sources of error which may arise by employing method IV., which was chosen by the British Association Committee in 1873, and which is too well known to need description.

In order to determine the absolute resistance of the revolving coil, the following investigations are necessary:—

1. The measurement of the space enclosed by the windings of the coil, to which the induction is proportional, as well as their form, on which depends the induced extra current, and also the moment of rotation exerted on the needle. These measurements are beset with very great difficulties. The successive layers of wire are liable to displace each other by the upper ones crowding in on the lower ones. In winding the coil a certain elongation of the wire is produced, which may amount to six per cent. of the whole length. The insulating material may be compressed. These defects are more pronounced in the case of thin wires than with thick ones. Thus it is not safe to calculate the space enclosed by the coil from the length of the wire either before or after coiling, and the circumference of the ring. The inner diameter of the ring can be readily determined by a cathetometer or by direct measurement with a steel tape; but it is not so easy exactly to determine the outer diameter. Supposing that there was an error of only 0·5 mm. in the mean diameter (314 mm.) of the coil used by the British Association Committee, this would make the area incorrect by about 0·32 per cent. The best method of obviating this error, as pointed out by W. Weber and Lord Rayleigh, is to make the diameter of the ring as large as possible, and to determine the exact diameter of each layer of the wire before proceeding to the next one. A more important error is due to uncertainty in the determination of the exact positions of the convolutions relatively to each other, on which depends the intensity of the extra current produced by the rotation of the coil. The fact that the coil is necessarily split in two, in order to allow of the passage of the suspending fibre of the magnet, is also liable to introduce error, owing to the parallelism of the two portions not being exact.

2. The temperature of the coil should be very exactly measured, since the conductivity of the wire diminishes by about 0·3 per cent. for an increase of 1° C.

3. It is necessary to take care that no secondary currents are induced in the stand of the apparatus by the currents in the coil. This may best be accomplished by making the stand of some badly-conducting material.

4. The verification of the symmetry of the several layers of the coil with respect to the axis of rotation can be readily effected by observations with a telescope.

5. It can also be determined by optical methods whether the axis of rotation remains rigidly vertical during the experiments.

6. The counting of the number of turns in the unit of time, as well as the maintenance of a uniform velocity, ought not to present any great difficulties.

7. The exact centring of the magnet can also be readily effected.

8. The moment of the magnet can be found by oscillation observations or by deflection. If, in order to get rid of the inductive action of the magnet on the revolving coil, magnets of very small moment are used, the friction of the air may introduce considerable errors into the determination of the moment by the method of oscillation.

9. The setting up the telescope and scale, for reading the position of the magnet, can be done in the customary way; but there is considerable difficulty in the exact determination of the distance of the scale from the centre of rotation of the magnet.

10. The force of torsion of the suspending fibre of the magnet can be readily compared with the directive force of the magnet, by rotating the fibres attached to a torsion circle through a fixed angle and observing the deflection of the magnet.

11. The effect of currents of air and of the shaking of the apparatus on the magnet must be determined by causing the coil to rotate when the circuit is open. F. Kohlrausch has shown that in the case of the magnet used by the British Association Committee, owing to the relatively large size of the mirror and magnet, the currents of air induced by the rotation of the coil in close proximity had considerable influence on the deflections.

Some of the above sources of error have been eliminated in the repetition of the experiments of the British Association Committee, lately made by Lord Rayleigh and Dr. Schuster, but others still remain. The author is therefore of opinion that for the final exact determination of the ohm by this fourth method, it is essential that its value should not be deduced from experiments made with an apparatus set up and corrected once for all; but that the apparatus should be successively altered in various points of its construction, and several series of observations made with each new arrangement. Only in this way can independent results be obtained, which can then be made use of to control each other.

W. Weber and F. Zöllher, adopting method No. I. for the determination of the ohm, made use of two similar coils wound on mahogany rings. One of these was fixed with a magnet suspended at its centre, and served as a galvanometer, while the other could be rotated by hand through 180 degrees about a vertical axis, the two coils being joined up by wires. The observations of the deflection were taken from two plane mirrors attached one at each end of a brass rod fixed at right angles to the magnet, the readings being made by means of telescope and scale. Owing to the method of double readings, the measurement of the distance of the scale from the magnet was obviated. It is of course necessary to place the inductor at such a distance from the galvanometer that the former has no direct influence on the needle of the latter.

Two great advantages of this method are, 1st, that the self-induction in the inductor is without influence; and, 2nd, that the intensity of the earth's horizontal force disappears from the results, provided that its value is the same for the positions of both inductor and galvanometer. If it should differ for the two parts of the apparatus, it can be readily determined for the position of each by means of oscillation experiments.

On the other hand, a double error may be introduced, owing to there being two coils, the exact dimensions of which must be calculated. But this error is probably very small in comparison with the determination of the coefficient of self-induction of the coil, as in the fourth method. The stability of the apparatus and its protection from air currents can, however, be more easily assured. On the whole, the author is inclined to think that this method (No. I.) would be very suitable for use in the final determination.

In method No. II., the dimensions of the galvanometer do not require to be taken into account, as the damping of the oscillations of the magnet are observed first when the circuit is open, and then when it is closed. From this, and the deflection of the needle when the inductor is rotated, the resistance of the coil can be calculated in electro-magnetic measure. It is necessary to determine, besides the dimensions of the inductor, the time of oscillation and the moment of inertia of the magnet, as well as the horizontal force of the earth's magnetism. The second method seems at first sight a very simple one, but a correct determination by means of it is attended with many difficulties, as it is necessary to know the value of the electro-motive force induced in the coil by the swinging magnet, and the reciprocal action of this E.M.F. on the magnet, which is directly proportional to the E.M.F., and inversely proportional to the resistance of the coil. Besides this, the exact dimensions of the coil have to be calculated, as well as the position of the needle relatively to the coil, and the distribution of the magnetism in the needle. F. Weber has used this method with an apparatus, the exact dimensions of which are given in the original article, to determine the value of a Siemens' standard unit, and found a mean value of 0·95451 from several observations which only differed by about a half per cent.

In a further series of experiments F. Weber made use of the following method:—He placed two coils at a fixed distance apart, and connected the inductor with a very constant Daniell's cell and a single ring of copper wire. The induced coil was in connection with a galvanometer of special construction, the single ring being placed between the two coils. The deflection of the needle, whilst a constant current circulated in the inductor, measured its intensity, I, which had to be determined in absolute measure from the known dimensions of the ring; the deflection obtained on breaking the inducing circuit, after cutting out the ring, gave the intensity, i, of the induction current. Since the induced electro-motive force, $e = \mathrm{I}\ \mathrm{P}$ (where P = the coefficient of mutual induction of the two coils), can be calculated in absolute measure from the dimensions of the coils, it follows that the resistance of the induced coil $r = \frac{e}{i}$.

In this method the following data are required:—The dimensions, 1st, of the

single ring; 2nd, of the inductor; 3rd, of the induced coil; 4th, of the galvanometer; 5th, the distance of the several convolutions of the two coils from each other; 6th, the determination of the position of the poles of the magnet; as well as due attention to the several details already mentioned in the consideration of the fourth method with regard to the symmetrical setting up of the apparatus. The horizontal force of the earth's magnetism does not enter into the calculations, since the intensities of the primary and of the induced current are both measured by the deflections of the same needle. Notwithstanding the complication of this method, F. Weber found that his standard Siemens' unit had the mean value 0·9554.

The same method was employed by Rowland, only he used a tangent galvanometer for the measurement of the intensity of the inducing current, and a second galvanometer for measuring that of the induced current. The sources of error in Rowland's experiments lay in the circumstances that, owing to the great number of convolutions on his coils, the compression of the insulating material, the squeezing together of the several layers, and the stretching of the wire were all considerable. Another element of uncertainty was that the galvanometer needle was supported on a pivot, and was not suspended by a fibre. Since the intensities of the inducing and induced currents were measured on two instruments in different positions, the exact value of the horizontal component of the earth's force for each had to be introduced into the calculation.

When by one or other of these methods the absolute resistance of a conductor, A, has been determined, it can be used for comparison with a column of mercury, B, which, with a cross section of 1 square millimètre, exactly represents the ohm. This comparison may be made by means of Weber's method No. I., or by using a differential galvanometer, or, still better, a Wheatstone's bridge. Since the length of the mercury column representing an ohm is already known very approximately, the resistance of B is taken nearly equal to that of A. For very exact measurements, screw connections should not be used, but the necessary contacts should be made by means of mercury cups, the resistance of which has been determined beforehand. It is very essential to maintain the temperature of the whole apparatus at the right point. A difficulty also arises from the production of secondary currents by the makes and breaks in the circuit. To obviate this, either a constant current should be employed, which is so weak as not sensibly to raise the temperature of the circuit, or, as F. Kohlrausch has proposed, an induction coil should be used so as to send alternating currents through the circuit. Great attention has also to be paid to the filling of the tube with mercury, and to the manner of connecting up the tube with the rest of the circuit. This may best be done by bringing the ends of the tube into relatively large glass vessels, due allowance being made for the resistance of the mercury in these vessels.

Weber's method No. IV. has quite lately been adopted by Carey Foster and Lippman, to compare the resistance of a column of mercury with that of a coil which was known in absolute measure. Professor Foster's experiments, which have been fully described in a report presented to the British Association at

the meeting at York, have been noticed in the scientific journals, and do not call for a detailed description in the present abstract.

The values of the ohm hitherto obtained by the various methods are not very concordant, notwithstanding the great care taken by the several experimenters to arrive at accurate results. Thus the resistance of a mercury column, 1 square millimètre in section and 1 mètre long at 0° C., as deduced from the first determination of the British Association Committee, is equal to 0·9830, according to Kohlrausch it is 0·9717, according to Fr. Weber, 0·9550, while Lord Rayleigh and Mrs. Sidgwick have found the value, 0·9413. The original British Association ohm has the value 1·0196, according to the measurements of Kohlrausch, 0·9910 according to Rowland, while Rayleigh and Schuster have recently given the value as 0·9893.

The author therefore insists on the necessity of not deducing the final value from experiments made with any one apparatus, or according to any one method, but that, rather, several methods, introducing different sources of error, should be used, the several results being used to control each other. For this purpose, the various data already obtained should, without further delay, be compared with each other, so as to lead to the determination of a final value, which shall rest on undoubted authority.

The determination of the ohm will not terminate the labours of the commission entrusted with the fixing of the electrical units. They will have to decide on the value of one of the two remaining units ,*e.g.*, the volt. Since, however, it will not be practicable to choose a standard for this latter which can always be exactly reproduced, it will always be necessary to compare electro-motive forces with the E.M.F. of a constant element, the value of which in volts is accurately known. It has been sufficiently proved that Latimer Clark's standard cell can be reproduced with great exactitude, if due care be taken in setting it up; but it is scarcely fitted for other than electrostatic measurements, owing to its becoming quickly polarised by somewhat strong currents. Similar indirect methods are requisite for measuring the unit of current; for instance, the reduction factor of the galvanometer has to be calculated. The latest investigations of Kohlrausch and Mascart on the electro-chemical equivalent of silver have considerably diminished the difficulties of this measurement.

For accurate results to be obtained, it is, however, essential that future investigations should be carried out as forming part of some settled and definite plan.

[NOTE.—Although the present abstract has exceeded the usual limits, many important points and details have necessarily been omitted. For these, the reader is referred to the original article, which will well repay further study.—*Translator.*]

THE SOCIETY OF

Telegraph Engineers and of Electricians.

COUNCIL.—1882.

President.

LIEUT.-COLONEL C. E. WEBBER, R.E.

Past-Presidents.

CHARLES WILLIAM SIEMENS, D.C.L., F.R.S.—1872 AND 1878.
FRANK IVES SCUDAMORE, C.B.—1873.
SIR WILLIAM THOMSON, LL.D., F.R.S.—1874.
LATIMER CLARK, C.E.—1875.
C. V. WALKER, F.R.S.—1876.
PROFESSOR ABEL, C.B., F.R.S.—1877.
LIEUT.-COL. J. U. BATEMAN-CHAMPAIN, R.E.—1879.
W. H. PREECE, F.R.S.—1880.
PROFESSOR G. C. FOSTER, F.R.S.—1881.

Vice-Presidents.

WILLOUGHBY SMITH.
PROFESSOR W. G. ADAMS, F.R.S.
C. E. SPAGNOLETTI, M. Inst. C.E.
PROFESSOR D. E. HUGHES, F.R.S.

Members.

W. S. ANDREWS.
WILLIAM T. ANSELL.
SIR CHARLES BRIGHT, M. Inst. C.E.
E. B. BRIGHT.
THE EARL OF CRAWFORD AND BALCARRES, F.R.S.
H. G. ERICHSEN.
H. C. FORDE, M. Inst. C.E.
MATTHEW GRAY.
J. FLETCHER MOULTON, F.R.S.
ALEXANDER SIEMENS.
AUGUSTUS STROH.
C. F. VARLEY, F.R.S.

Associates.

Captain J. T. BUCKNILL, R.E.
CHARLES H. B. PATEY.
T. RUSSELL CRAMPTON, M. Inst. C.E.

OFFICERS.

Auditors.

J. WAGSTAFF BLUNDELL, 12, Delahay Street, Westminster, S.W.
FREDERICK C. DANVERS (India Office).

Hon. Treasurer.—EDWARD GRAVES.

Hon. Secretary.—LIEUT.-COL. FRANK BOLTON.

Hon. Solicitors.

Messrs. WILSON, BRISTOWS & CARPMAEL, 1, Copthall Buildings, E.C.

Chairman of the Editing Committee.—PROF. W. E. AYRTON, F.R.S.

Librarian.—ALFRED J. FROST.

Secretary.—F. H. WEBB.

Bankers.

Messrs. COCKS, BIDDULPH & Co., 43, Charing Cross, S.W.

Library and Offices of the Society.

4, The Sanctuary, Westminster, S.W.

LOCAL HONORARY SECRETARIES AND TREASURERS.

JAMES ALLEN, Telegraph Superintendent, Great Southern Railway, Buenos Ayres	ARGENTINE & ORIENTAL DEL URUGUAY REPUBLICS.
Don JOSÉ APARICIO, Representative of the Direct Spanish Telegraph Company, Calle de Fernando VI., Numº 1, Madrid	SPAIN.
JOHN AYLMER, Civil Engineer, 4, Rue de Naples, Paris	FRANCE.
J. M. COLLETTE, Engineer of the Netherlands Telegraphs, The Hague	The NETHERLANDS.
E. C. CRACKNELL, Superintendent of Telegraphs, Sydney	NEW SOUTH WALES.
JAMES DAKERS, Manager, Montreal Telegraph Company, Montreal	CANADA.
Le Commandeur E. D'AMICO, Director-General of the Italian Telegraphs, Rome	ITALY.
FRÉDERIC DELARGE, Engineer of the Belgian Telegraphs, Brussels	BELGIUM.
N. ISPOLATOFF, Director of Telegraphs in St. Petersburg	RUSSIA.
CHARLES LEMON, Ph.D., Superintendent of the New Zealand Telegraphs, Wellington	NEW ZEALAND.
C. L. MADSEN, 49, Norre Sogade, Copenhagen	DENMARK.
SAMUEL W. McGOWAN, Chief Inspector of Telegraphs and Postal Service, Melbourne	VICTORIA.
C. NIELSEN, Director-General of the Norwegian Telegraphs, Christiania	NORWAY.
J. R. PREECE, Indo-European Government Telegraphs, Shiraz	PERSIA.
E. ROSENBUSCH, A.M. Inst. C.E., Engineer, Mediterranean Extension Telegraph Company, Valetta, Malta	MALTA AND THE MEDITERRANEAN.
Dr. WERNER SIEMENS, 94, Markgrafen, Strasse, Berlin	GERMANY.
J. SIVEWRIGHT, M.A., General Manager of Telegraphs, Cape Town, Cape of Good Hope	THE CAPE AND SOUTH AFRICA.
F. G. TEALE (Acting Local Hon. Sec. and Treasr.), Indian Government Telegraphs, Calcutta	INDIA.
CHARLES TODD, C.M.G., Director-General, South Australian Telegraphs, Adelaide	SOUTH AUSTRALIA.
G. G. WARD, Gen. Superintendent of the Direct United States Cable Company, New York	NORTH AMERICA.
WILLIAM WARREN, Superintendent in Tasmania of the Eastern Extension Australasia and China Telegraph Company, George Town	TASMANIA.

JOURNAL

OF THE

SOCIETY OF

Telegraph Engineers and of Electricians.

VOL. XI. 1882. No. 44.

The One Hundred and Fourteenth Ordinary General Meeting of the Society was held on Thursday evening, November 9th, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Colonel C. E. WEBBER, R.E., President, in the Chair.

The minutes of the last meeting were read and confirmed, and the names of new candidates were announced and suspended.

The SECRETARY read the following list of donations to the Library:—

Presentations to the Library since May 25th have been made by the Admiralty; Borough of Leeds; French Ministry of Posts and Telegraphs; H.M. Patent Office; Philosophical Society of Glasgow; Royal Institute of British Architects; G. M. Borns, Esq.; Dr. G. Gore, F.R.S.; Herr A. Hartleben; W. Haywood, Esq.; Dr. Oliver J. Lodge; H. R. Meyer, Esq.; G. A. Rowell, Esq.; Messrs. Siemens and Halske; M. Armengaud, jeune, F.M.; Colonel V. Hoskiœr, F.M.; Mr. Latimer Clark, P.P.; Dr. C. W. Siemens, F.R.S., P.P.; Sir William Thomson, F.R.S., P.P.; Mr. Willoughby Smith, V.P.; Mr. Conrad W. Cooke, M.; Mr. James D. Doyle, M.; Mr. R. S. Newall, M.; Mr. C. Todd, C.M.G., M.; Captain H. Watkin, R.A., M.; Dr. William H. Stone, A.; large medallion cast of Oersted, by Mr. H. G. Erichsen, Member of Council.

The PRESIDENT: In addition to the presentations, of which the list has just been read, the Society has received the Diplôme d'Honneur that was granted to it at the Paris Exhibition. It is proposed to instruct the Secretary to communicate the best thanks of the Society to the different donors of books and objects.

A paper will now be read by Lieut.-Col. Bolton, which will form a short addition to his Historical Notes on the Electric Light, bringing the subject up to September 30th, 1882.

The valuable paper contributed by Col. Bolton to the proceedings of the Society in the year 1879 will probably be in the memory of many present.

The following paper was then read:—

SOME FURTHER HISTORICAL NOTES ON THE ELECTRIC LIGHT, BRINGING THE SUBJECT UP TO THE 30TH SEPTEMBER, 1882.

By Colonel FRANK BOLTON, Hon. Secretary.

The paper on Electric Lighting which I had the honour to read before the Society in May, 1879,* met with so favourable a reception, while, as I am assured, it has not been without value to those interested in the subject, that I have been encouraged and induced to continue the work, with a view to bringing it down as far as possible to the present time. In 1879 the conditions were different from what they are now. Then the subject of electric lighting was comparatively a new one, and the number of specifications to be examined, although extending over a number of years, was considerably less than the number issued between 1879 and the present year of grace. From an historical point of view, my former paper necessarily possessed far greater interest for the student than the present one can possibly do, as it embraces so brief a period.

I have unavoidably been led to deviate in some respects from the plan formerly adopted, and to make this paper of a somewhat more practical character, in the desire to assist the student in his

* *Journal Soc. Tel. Eng.*, Vol. VIII., 1879, p. 217.

investigation of that particular system of electric lighting which may happen to be the subject of his search.

The abstracts of specifications given under each heading do not pretend to be even a *précis* of the whole of each patent. Indeed, such a compilation would be entirely beyond the scope of this paper or the limits allowed by the Society's Journal. The number of patents which have been taken out since the date of my last paper has been so great, exceeding 550, as to almost cause me, when I found the mass of work to be done, to hesitate before continuing it; nor should I have done so had I not known the great difficulty there is in obtaining even a mere list of the numbers, dates, and titles of the various patents on any particular subject, and therefore believed I could not fail to render some slight service to Electrical Engineers by undertaking this task.

Although in 1879 electric lighting was beginning to create considerable interest in the public mind, it had not assumed the vast importance it now possesses. The enormous amount of capital that has lately been embarked in various electrical undertakings, and the great number of persons not electricians who are connected with the subject, render it more than ever necessary that some system of classification should be attempted. It might well be thought that such a work should properly be performed by the Commissioners of Patents, who have the funds and all the material at their disposal for the purpose. Apparently its desirability, not to say necessity, has failed to strike them. It is true that an Abstract of Specifications on Electric Lighting has been issued by the Patent Office, but, although a recent publication, it only goes up to 1876. It will probably be admitted, therefore, that its usefulness is very much impaired, and, however thankful we ought to be for small mercies, we have not here much to be thankful for.

The limited time that I have been able to devote to the matter, and the great difficulty that exists in making a satisfactory classification of the immense number of patents produced during the last few years, have rendered the work one of great labour and considerable difficulty. I can only offer the paper as supplementary to the previous one, in the hope that the mere

fact of bringing the various systems under one heading, with a few necessary subdivisions of all the published specifications to September 30, 1882, may prove of value to those who, in large and daily-increasing numbers, are devoting their attention to the subject of electric lighting.

I would here refer to the great assistance I have derived from the valuable collection of electrical patents presented to the Society by H.M. Commissioners of Patents. I have thereby been enabled to have laid before me week by week the whole of the published specifications on electricity and magnetism as soon as they were issued to the public, a fact which, I think, speaks well for the management of our Library.

I would, however, suggest that, if the specifications were classed under their various headings, and bound up, or a classified index of them made, the labour of searching for any particular patent would be considerably lessened.

CONTENTS.

(The first portion of this paper will be found in the Society's Journal, Part No. 27, Vol. VIII., 1879.)

SUBDIVISION I.

DYNAMO- AND MAGNETO-ELECTRIC MACHINES.

I.—OF THE WILDE TYPE.

1878. J. IMRAY. **4066.**

(From Société Générale d'Électricité.)

Improvements in Magneto-Dynamo-Electric Machines.

Describes the use of copper discs revolving with electro-magnet coils fixed on the periphery of same, and placed with their axes parallel to the axle of the machine. Opposite the ends of the revolving armature electro-magnet coils, are the field electro-magnets fixed to a copper disc.

1878. C. F. HEINRICHS. **4595.**

Improved Means and Apparatus for Generating Electric Currents, etc.

Describes a machine with eight electro coils placed on the periphery of a wheel, with their axes parallel to the axis of machine; the armature revolves between the poles of four field electro-magnets, also with their axes parallel to the axis of machine.

1878. J. T. SPRAGUE. **4762.**

Improvements in Machines and Appliances for Generating Electric Currents, etc.

Describes a machine similar to the "Alliance," the currents being due wholly to the magnetising and demagnetising of the cores. In this machine the cores are made of sheet iron, each layer being insulated one from the other, and made to form part of the circuit, thereby utilising the tendency to set up an electric current in the core itself.

1878. JOHNSON. **5076.**

See Machines—Gramme type.

1879. C. DUBOS. **749.**

A Galvano-Magneto-Dynamo-Electric Machine.

Describes a machine with several sets of revolving armatures. The coils have iron cores, and are placed on the periphery of wheels, with their axes parallel to the axis of machine; the coils rotate between polar extensions of the field magnets, constructed with an annular core.

1879. **W. ELMORE.** 3565.

Improvements in Dynamo Machines.

Describes a machine with the armature electro-magnet coils fixed to the periphery of a wheel, with the axes of the coils parallel to the axis of machine. Opposite the poles of the revolving armature coils are the field electro-magnets, with their axes also parallel to the axis of machine.

1880. **W. R. LAKE.** 1998.

(From C. A. SEELEY.)

Improvements in Magneto-Electric Machines.

Describes a machine with an armature made as nearly as practicable in the form of a disc, and revolving between magnetic poles of opposite name, and which may be considered a modification of "Arago's disc," whereby the induced currents of the disc are utilised.

1880. **W. ELMORE.** 3832.

Improvements in or applicable to Dynamo-Electric Machines.

Describes improvements in machine described in Patent No. 3565, 1879, and which consist in providing a hollow axle, and in having hollow iron cores to the revolving armature coils, to allow of a free passage of a cooling medium.

1880. **A. M. CLARK.** 3971.

(From A. NIAUDET and E. REYNIER.)

Improvements in Dynamo-Electric and Magneto-Electric Machines.—(Provisional.)

In this machine the rotating armature consists of single electro-magnet coils mounted on the periphery of a drum; opposite each end of the two coils, situate on opposite sides of the drum, are placed the field magnets, with a north pole at one end of the coil and south pole at the other.

1880. **E. G. BREWER.** 4005

(From A. J. B. CANCE.)

Improvements in Dynamo-Electric or Magneto-Electric Machines.

Describes a form of machine where the revolving coils are composed of one or several induction crowns or rings formed of bobbins placed circularly and parallel to axle of machine; these bobbins revolve between the poles of inducing electro-magnets.

1880. **A. W. L. REDDIE.** 4049.

(From A. BILORET and C. MORA.)

Improvements in Dynamo- and Magneto-Electric Machines.

Describes a machine with two sets of revolving armature electro-magnet coils, with their axes parallel to the axle of machine. One set of coils is placed or mounted within the other, between two cheeks of non-magnetic material and wound on projecting arms, and forming the periphery of a wheel; the coils rotate between four polar extensions of the field electro-magnets.

1880. J. HOPKINSON and A. MUIRHEAD. 4886.

Improvements in Dynamo Machines.

Describes a machine the revolving armature of which consists of superposed rings or layers of sheet-iron with radial grooves for the coils, the coils lying in planes perpendicular to the axis of rotation. Also describes the field electro-magnets as having cores made up either of superposed layers of sheet iron or cast-iron grooved and inlaid with sheet-iron.

1880. H. WILDE. 5008.

Improvements in Electro-Magnetic Induction Machine.

(Void—Specification not filed.)

Describes a machine with the armature revolving, and the fixed field electro-magnet coils arranged on the periphery of metal discs, with their axes parallel to the axis of machine. The improvement described is in having a slot in the discs and also in the ends of the coils, to allow of easy manufacture.

1881. J. E. H. GORDON. 78.

Improvements in Dynamo-Electric Machine for Electric Lighting.

Describes a machine with two sets of revolving armature electro-magnet coils; each set is mounted on the periphery of a wheel, and are parallel to axle of machine. Between the two revolving electro-magnet armature coils are the fixed electro-magnet coils, the ends of the cores of which are opposite the cores of the revolving armature cores, and are fixed parallel to axle of machine.

1881. H. WILDE. 497.

Improvements in Electro-Magnetic Induction Machines.

Describes a machine where the field electro-magnet coils, also the revolving armature coils, are placed parallel to the axle of machine. The metal discs on which the armature coils are mounted are slit in a radial direction.

1881. C. W. SIEMENS. 1447.

(From Siemens and Halske.)

Improvements in Dynamo-Electric Machines.

An even number of stationary magnetic fields of alternating polarity are combined with a number of revolving alternately wound coils differing by two or other even number from the number of fields, the wires of the coils being all connected to one another and to a commutator.

1881. A. M. CLARK. 1787.

(From H. J. Müller and A. Levett.)

Improvements in Dynamo-Electric Machines.

Describes a form of machine where the armature consists of a number of electro-magnet coils (pear shape in section) mounted on the periphery of a wheel, the armature revolving between two sets of field magnets, where six

electro-magnets are joined up in each set; the armature electro-magnet coils are placed so that the end of the coil enters one field before the other part leaves the other field.

1881. L. A. GROTH. 2761.
(From D. Lachaussée.)

A New or Improved Electro-Magnetic Induction for Dividing a Direct Current into Alternate Currents.

Describes a machine with the armature coils fixed, consisting of coils of wire (oval in section) fixed in recesses provided for that purpose in a circular wood frame; the axes of coils are parallel to the axis of machine. Field electro-magnets are placed on each side of the armature coils; they are mounted on metallic discs, and made to revolve.

1881. ST. GEORGE LANE-FOX. 3394.

Improvements in Means or Apparatus for Generating Electric Currents, etc.

Describes a machine with the revolving armature coils placed on the periphery of a circular block of wood, with their axes parallel to axle of machine, and are held in position by being bound round with strong string. On both sides of armature coils are the polar extensions of the field electro-magnets.

1881. F. E. FAHRIG. 4107.

An Improved Dynamo-Electric Machine.

Describes a machine with revolving armature electro-magnet coils mounted on the periphery of a wheel, and placed parallel to axle of machine; the intermediate spaces between the coils being filled with segment-shaped plates, the armature revolving between eight poles of field electro-magnets, four on each side of armature coils.

1881. H. AYLESBURY. 4304.

Improvement in Dynamo Machines for the Production and Distribution of Electric Currents.

Describes a machine with a number of electro-magnets placed on each side of the periphery of a wheel; opposite the pole of the revolving electro-magnets are fixed field electro-magnets.

1881. J. E. H. GORDON. 5536.

Improvement in Dynamo-Electric Machines.

Describes improvements on the machine described in patent No. 78 of 1881, which consists in using twice the number of armature coils to that of magnet coils.

1881. L. S. POWELL. 5593.
(From J. M. A. Gerard-Lescuyer.)

Improvements in Dynamo-Electric Machines.

Describes a machine with the armature revolving electro magnet coils

placed on the periphery of a wheel, the axes of the coils being parallel to the axle of the machine; opposite each end of the revolving armature coils are two circles of field electro-magnets of an oval or elliptical shape.

1881. S. A. VARLEY. 5665.

Improvements in Apparatus for Producing and Regulating Electric Light, etc.

Describes a machine with several sets of electro-magnet armature revolving coils, the coils being placed on the periphery of their respective wheels, and are placed with their axes parallel to the axle of machine. Between and facing the ends of each set of revolving coils are broad polar extensions of the field electro-magnets, one polar extension from each field electro-magnet being placed between each set of revolving coils.

1882. J. BROCKIE. 756.

Improvements in Machines for Producing Electric Currents.

Describes a machine with revolving armature electro-magnet coils mounted between two circular pieces or rings of metal, the axes of the coils being parallel to the axle of machine. The armature revolves between polar extensions of four field electro-magnets.

1882. C. E. SPAGNOLETTI. 869.

Improvements in Dynamo-Electric Machines and Apparatus connected therewith, for Lighting by Electricity, etc.

The electro-magnet coils are fixed to the ends of spokes radiating from a boss on the axle of the machine. The axes of the coils are parallel to the axis of the machine. The coils rotate between polar extensions of field electro-magnets.

Also describes rotating the armature in one direction, and field electro-magnet in opposite direction.

Also describes an arc lamp with carbons placed at an angle, and which are held by rods connected to a piston working in cylinders containing mercury or other fluid.

II.—OF THE GRAMME TYPE.

1878. CARL H. SIEMENS. 3134.

Improvements in Apparatus for the Dynamical Production and Application of Electricity, and for its Regulation when applied for Illumination.

Describes a machine with the armature revolving coils wound on an iron ring, and arranged to form the periphery of a wheel. The armature revolves between successive fields of opposite polarity.

Also describes electric currents generated by means of copper cylinders.

1878. J. H. JOHNSON. 3658.

(From A. DE MERITENS.)

Improvements in Magneto-Electric and Electro-Magnetic Machines.

Describes a machine with the armature revolving coils wound on iron cores with projecting poles, and placed end to end, and forming the periphery of a wheel. The armature rotates at the ends of a number of permanent magnets surrounding same.

1878. M. R. WARD. 3976.

Improvements in Magneto-Electric Machines or Machines for Generating Electricity.

Describes a machine with the armature revolving coils wound on bars of H iron, the ends being placed together and arranged to form the periphery of a wheel. The armature revolves between, and is embraced by two polar extensions of the field electro-magnets.

1878. R. P. HIGGS. 4206.

Improvements in Magneto- or Dynamo-Electric Machines.—(Provisional.)

Describes a machine with a revolving armature consisting of coils of wire wound on iron cores. The ends of the cores are placed against each other and form an annular core. The coils are embraced on opposite sides by polar extensions of the field electro-magnets.

1878. G. ZANNI. 4573.

Improvements in the Production of Light by Electricity, etc.

Describes a machine with the armature revolving coils wound on iron cores which are made so that the ends of the cores can be fitted together with tongues and grooves. Also describes the field electro-magnets made with hollow cores to allow water to circulate freely to keep them cool.

1878. J. H. JOHNSON. 5076.

(From DE MERSANNE.)

Improvements in Electro-Magnetic and Magneto-Electric Machines.

Describes a machine with the armature revolving coils placed on the periphery of a wheel, and with their axes parallel to the axis of machine. Field electro-magnet coils are placed with their poles opposite the ends of the revolving armature coils.

Also describes the use of an armature with coils wound round an annular core.

1878. W. B. BRAIN. 5139.

Improvements in Apparatus for the Production and Application of Electricity for Lighting and other purposes.

Describes a machine with the armature revolving coils wound on an annular core and embraced by two polar extensions of the field electro-magnets.

Also describes the use of an armature with electro-magnet coils radiating from the axle of machine.

Also describes a lamp with horizontal carbons; also one with several carbons radiating from one point where the arc is formed.

1879. J. FORMBY. **565.**

Improvements in the Construction of Dynamo Machines employed for Generating Electric Currents.

Describes a machine with the armature revolving coils wound on an annular iron core, with the ends of the field electro-magnets facing one side of the armature.

1879. L. SIMON. **960.**

(From S. Schuckert.)

Improvements in Dynamo-Electric Machines.

Describes a machine with the armature revolving coils wound round an annular iron core consisting of several sheet-iron discs placed together; the armature revolves between the poles of field electro-magnets placed on each side of the armature.

1879. J. S. SELLON and H. EDMUNDS. **1949.**

Improved Apparatus for Generating Electric Currents.—(Provisional.)

Describes a revolving armature with coils of wire wound on iron cores, each coil being provided with end plates; the coils are segment-shaped in section. The flanges of the coils are screwed together and form an annular armature. On each side of the armature coils are the field electro-magnets, one set revolving in one direction, while the other set revolves in the opposite direction, the armature being fixed.

1879. W. R. LAKE. **4400.**

(From E. J. Houston and E. Thomson.)

Improvements in and relating to Generating, Storing, and Application and Utilisation of Electricity, etc.

Describes a machine with the revolving armature constructed with electro-magnets radiating from the shaft, between the ends of which are coils of wire wound round an iron core.

Also describes a lamp with vertical carbons, the lower carbon being fixed and attached to the armature, which is attracted when the current is applied to form the arc. The upper carbon is attached to a rod with a rack on one side which gears into a pinion, on the axle of which is another wheel which is regulated by a ratchet-wheel and pawl, the pawl being actuated by an armature opposite an electro-magnet.

1879. C. F. HEINRICHS. 4589.

Improvements in Apparatus for Generating Electric Currents, also in Electric Lamps and in the Manufacture of Carbons to be used therewith, etc.

Describes a machine with the armature revolving coils wound round an iron core of a section representing the letter U.

Also describes a lamp with semicircular carbons.

1879. W. L. WISE. 5085.
(From E. BURGIN.)

Improvements in Dynamo-Electric Machines and Electro-motive Engines.

Describes a machine with a number of sets of revolving armature coils wound round cores of iron, and placed side by side and mounted on an axle. They are embraced by two polar extensions of field electro-magnet coils.

1880. R. WERDERMANN. 79.

Improvements in Apparatus for Producing and Utilising Electric Currents, and in Lamps to be employed in connection with the same or similar Apparatus.

Describes a machine with very large revolving coils of the Gramme type, each coil forming an open circuit.

Also describes a double form of globe, one inside the other. The space between the two globes is exhausted of air and filled with oxygen. The outer globe is provided with wires or conducting strips, and the inner globe with a coating of conducting material; the light is given off by the discharge between one globe and another through the oxygen.

1880. LAKE. 315.
See Machines—Siemens type.

1880. T. MORGAN. 478.
(From N. GLOUCHOFF.)

Improvements in Electro-Magnetic and Dynamo-Electric Machines.—(Provisional.)

Describes a machine with revolving armature coils wound on an iron core. The poles of permanent field magnets are placed round and on each side of the coils.

1880. D. FITZGERALD. 872.

Improvements in Magneto-Electric and Dynamo-Electric Machines, etc.

Describes a machine where the revolving armature coils are wound on the periphery of a wheel which is circular in section. Three sets of field electro-magnet coils (termed "saddle back magnets") embrace the revolving coils.

1880. J. PERRY. 1178.

A Dynamo Machine to Convert Mechanical Energy into Electricity.

Describes a machine with revolving armature coils wound obliquely on an

iron ring. The coils form an angle of from 20° to 70°, with the poles of field electro-magnet coils placed on each side of the armature.

1880. LAKE. 1392.

See Machines—Siemens type.

1880. E. P. ALEXANDER. 1580.

(From K. Zipernowskij.)

Improvements in Dynamo-Electric Machines.

Describes a machine the armature of which is cylindrical, and wound lengthwise with wire. The existing electro-magnets are of a ring shape and surround the armature, and are wound in sections with wire, so as to produce a number of successive polar fields of alternating polarity.

1880. W. R. LAKE. 4265.

(From C. A. Hussey and A. S. Dodd.)

Improvements in Dynamo-Electric Machines.

Describes a form of machine where the revolving armature has radial projections and intervening spaces, the field magnets being of a circular form, with two pole-pieces on either side.

1880. C. HEINRICHS. 4608.

Improvements in the Means and Apparatus for Generating, Subdividing, and Transmitting Electric Currents, also in Electric Lamps.

Describes a machine with the armature revolving coils wound round hollow annular iron cores, various sections of which are shown.

Also describes a lamp with carbons of semicircular shape, and arranged to approach each other by the weight of the holders, and regulated by means of wheels and racks and electro-magnets.

Also describes a lamp with vertical carbons, the electrodes being contained within tubes and made to approach each other by means of spiral springs contained in the tubes; the taper ends of carbons press against abutment poles at the end of the tubes.

1880. W. T. HENLEY. 5137.

Improvements in Dynamo-Electric Machines and Apparatus for Production of Light, etc.

Describes a machine with a revolving armature fitted with a number of soft iron pieces on its circumference, and revolving between two sets of field electro-magnets, the poles of which are not opposite to, but intermediate between each other.

Also describes a machine with two armatures with coils revolving at each end of a number of field electro-magnets.

Also describes a lamp using circular carbon discs, the light being given off at periphery.

1881. **P. HIGGS.** 1961.

Improvements in Magneto-Electric Machines, in their Circuits, and in the Method of operating them.

Describes a machine with revolving armature coils. Each coil of wire is wound between iron pole-pieces which are placed end to end and constructed to form a ring; they are mounted on the shaft by spokes fixed to a box on same. The coils are completely embraced and surrounded by iron pieces connected with the poles of the field electro-magnets.

1881. **H. E. NEWTON.** 2375.

(From C. A. HUSSEY and A. S. DODD.)

Improvements in Magneto-Electric Machines, etc.

Describes a machine with revolving armature coils wound on an iron ring with alternate inward and outward projections; the coils are wound between these projections. Encircling the armature are a number of circular iron rings which can be magnetised in any part by applying powerful electro-magnets.

1881. **F. WOLFF.** 2416.

(From C. P. JURGENSEN and L. V. LORENZ.)

A Magneto-Electric Machine.

Describes a machine with the revolving armature coils wound round an annular iron core, the armature being embraced by and between two polar extensions of field electro-magnets of horse-shoe shape.

1881. **R. R. MOFFATT and S. CHICHESTER.** 3441.

Improvements in Apparatus for Producing Electricity, etc.

Describes a machine with revolving armature coils wound round an iron ring, the coils having a greater length parallel to axle of machine. The coils are embraced by extended poles of field electro-magnets.

Also describes a lamp with vertical carbons, the bottom carbon being attached to a holder fitted to an iron core working in a solenoid, and is used to form the arc. The top carbon is attached to a rod which is held by a clutch lever. This lever is actuated by an armature pivoted in the centre, with two electro-magnet coils facing same; one coil is wound with thick wire, and is in main circuit, the other is wound with fine wire, and is in shunt circuit, thereby giving an oscillating movement to the armature, and moving the clutch.

1881. **W. R. LAKE.** 3456.

(From A. L. AREY.)

Improved Electrical Apparatus for Lighting and other purposes.—(Provisional.)

Describes a lamp with mechanism provided with vibrating armatures connected with the upper carbon-holders.

Also describes a machine with revolving armature coils rotating between polar extensions of two helices, broad in section and placed one above and one below the revolving coils.

1881. **E. J. HARLING and HARTMAN.** **3472.**

Improvements in the Construction of Dynamo-Electric Machines.

Describes a machine with armature revolving coils wound round an iron ring, and revolving between four polar extensions of field electro-magnets.

1881. **H. A. HARBOROW.** **3871.**

Improvements in Dynamo-Electric Machines.—(Provisional.)

Describes a machine with two sets armature revolving coils. The inner set of coils are wound longitudinally, and revolve within and in an opposite direction to a second armature wound with wire in segments. Both armatures are embraced by the extended poles of the field electro-magnets.

1881. **W. R. LAKE.** **3880.**

(From C. Dion.)

Improvements in the Manufacture of Revolving Armatures and other parts of Electrical Apparatus, etc.

Describes a revolving armature, which consists of an insulated copper ribbon wound edgewise on an iron ring.

1881. **C. A. BARLOW.** **4207.**

(From A. De Meritens.)

Improvements in Dynamo-Electric Machines.

Describes a machine with the armature revolving coils wound round an annular iron core arranged to rotate between polar extensions of four clusters of permanent magnets, the four clusters forming two horse-shoes.

1881. **H. KENNEDY.** **4541.**

Improvements in Generation, Collection, and Distribution of Electro-Magnetic Currents, etc.

Describes a machine with a number of sets of armature revolving coils consisting of coils of wire wound on an iron ring placed close together on one shaft. The whole are embraced and rotate between extended pole-pieces of the field electro-magnets.

1881. **H. F. JOEL.** **4607.**

Improvements in Magneto-Electric Machines.

Describes a machine with armature revolving coils wound round a core in the form of a ring, and forming the periphery of a wheel with non-magnetic arms and bars, the ring having projections between which the coils are wound. The coils revolve between flat polar extensions of the field electro-magnets placed on each side of the coils.

1882. L. A. GROTH. 64.

(From R. J. GULCHER.)

Improvements in Magneto- and Dynamo-Electric Machines.

Describes a machine which is constructed with the object of reducing the heating of same. The revolving armature coils have an iron core consisting of a number of flat iron rings placed side by side and insulated from each other. The section of the core can be either wedge shape or partly rectangular and wedge shape. Polar extensions of the field electro-magnets surround the opposite sides and periphery of the revolving armature.

1882. W. T. HENLEY. 130.

Improvements in Machinery and Apparatus for Obtaining, Transmitting, and Applying Electric Currents, etc.

Describes a machine with two sets of revolving armature coils, each set being mounted on a wheel with the wire wound in coils round the periphery and between projecting pieces of iron on the same. The field electro-magnets are placed between the two revolving armatures, which are single coils and are placed parallel to axle of machine at a distance from axle equal to distance of projecting pieces on the periphery of armature.

1882. W. R. LAKE. 234.

(From C. A. HUSSEY and A. S. DODD.)

Improvements in and relating to Electric Light Machines.

Describes a machine with the core of revolving armature forming the periphery of a wheel with metal projections, between which the coils of wire are placed. The field magnets surround the armature revolving coils, and consist of pieces of iron, each provided with two projections between which the coils are wound. A number of these pieces of iron with their respective coils are placed side by side, and form a complete circle outside the armature coils.

1882. J. D. F. ANDREWS. 540.

Improvements in Dynamo-Electric and Electro-Dynamic Machines.

Describes a machine with several convolutions of revolving armature coils. The coils are wound round a long iron core, and the coils so wound are placed spirally round a drum of non-magnetic metal fixed to the axle of machine, the coils being embraced in polar extensions of the field electro-magnets.

1882. C. W. SIEMENS. 760.

(From E. W. SIEMENS.)

An Improved Dynamo-Electric or Electro-Dynamic Machine.

Describes a machine with a circular ring or tube of iron forming a core, 270° of the circumference of which is of iron, the other part being filled with non-magnetic metal; it is made to rotate by means of gearing attached to the

shaft of the machine within the middle of fixed coils wound lengthwise round the iron of the ring.

1882. W. R. LAKE. 834.

(From B. Lande.)

Improvements in Electric Lighting Apparatus.

Describes a machine which is constructed for the purpose of obtaining a free circulation of air in the revolving armature coils; air passages are also provided in the iron core. The armature coils are of oblong shape, and wound on a flat iron ring forming the periphery of a wheel. The opposite parts of the periphery are completely embraced in polar extensions of the cores of the field electro-magnets.

1882. A. M. CLARK. 931.

(From H. B. Sheridan.)

Improvements in Dynamo-Electric Machines.

Describes a machine where the revolving armature coils (which are similar to Gramme coils) are wound on a hollow iron ring of rectangular section. The field magnets are fixed at an angle relatively to the plane of the armature coils, and are placed on opposite sides of the same, and present flat polar extensions to each side of the armature coils.

1882. C. L. LEVEY and E. LUMLEY. 1249.

Improvements in Armatures for Magneto-Electric Machines and in Apparatus for Developing Electric Light.

Describes a machine with revolving armature coils wound round the periphery of a wheel which is constructed with alternate plates of magnetic and non-magnetic material. The coils revolve between polar extensions of field electro-magnets.

Also describes a lamp with vertical carbons. The bottom carbon is fixed; the upper carbon is attached to a rod held by a clutch ring connected to a rocking shaft, which is moved by an armature actuated by two differential electro-magnets.

1882. W. R. LAKE. 2531.

(From J. J. Wood.)

Improvements in Armature for Dynamo- or Magneto-Electric Machines.

Describes an arrangement for securing the Gramme revolving armature firmly on its limb by means of several projecting plates; they act as a carrier and maintain the core.

1882. J. IMRAY. 2744.

(From J. J. McTighe and J. T. McTighe.)

Improvements in Dynamo-Electric Machines and Electric Motors.

Describes a machine with revolving armature coils wound on a cylindrical

core constructed of annular rings of metal; the coils are oblong in section. The armature rotates between polar extensions of the field electro-magnet, and is constructed on the principle of De Molyen's, or "Altande" magnet.

1882. J. A. BERLY. 2885.
(From F. V. MAGUIRE.)

Improvements in Dynamo-Electric and Electro-Dynamic Machines.

Describes a machine with the armature revolving coils wound on separate iron cores, and mounted in the form of a wheel by pieces of non-magnetic metal. The armature revolves between the poles of field electro-magnets.

III.—OF THE SIEMENS TYPE.

1879. W. B. F. ELPHINSTONE and C. W. VINCENT. 332.

Improved Means of Obtaining Currents of Electricity.

Describes a machine with the revolving armature coils wound on the outside of a drum, the wire of each coil being wound and continued within the space of a sixth part of the circumference. The armature revolves and is embraced within the poles of three broad electro-magnet coils and the poles of other field electro-magnets within the armature and radiating from an arbor outside the axle of machine.

1879. EDISON. 2402.

See Lamps—Incandescent in Vacuum.

1880. W. R. LAKE. 315.
(From E. J. HOUSTON and E. THOMSON.)

Improvements in and relating to Apparatus for Generating Electricity.

Describes a machine with revolving coils similar to latest form of Siemens armature.

Also describes revolving armature having a core with ribs of soft iron, the coils wound similar to Gramme coils.

Also describes a form of arc lamp with vertical electrodes, the bottom carbon being fixed. The upper carbon is controlled by friction wheels attached to a wheel gearing into a pinion wheel fitted to an arm carrying three electro-magnet coils, which actuate the regulating apparatus for separating and allow ing the electrodes to approach each other.

1880. J. H. JOHNSON. 1259.
(From W. W. GRISCOM.)

Improvements in Dynamo-Electric Machines.

Describes use of a Siemens armature revolving on exciting electro-magnet made in the shape of an oval tube in section; this core is cut away on the side in which the Siemens armature revolves.

1880. **W. R. LAKE.** 1392.

(From H. S. MAXIM.)

Improvements in and relating to Dynamo-Electric Machines.

Describes using in connection with a dynamo-electric machine an arrangement for revolving the contact brushes on the commutator, and thereby automatically adjusting the amount of current sent out from machine.

Also describes a revolving armature, consisting of annular plates, and constructed so as to keep the coils separated from each other and leave air passages between them.

1880. **ALEXANDER.** 1580.

See Machines—Gramme type.

1880. **T. SLATER.** 2272.

Improvements in Obtaining, Increasing, and Employing Currents of Electricity, etc.

Describes a machine with a revolving armature consisting of a coil of wire wound round an iron core.

Also describes the placing of two coils so wound side by side, and rotating between the poles of field electro-magnets.

1880. **W. B. F. ELPHINSTONE and C. W. VINCENT.** 2893.

Improvements in Apparatus for Generating Electric Currents.

Describes improvements in the machine described in Patent No. 332, 1879, having an armature with revolving electro-magnet coils, broad in section and radiating from the axle of machine embraced by polar extensions of three sets of field electro-magnets.

1880. **C. G. GÜMPEL.** 3324.

Improvements in Dynamo-Electric, Magneto-Electric, and Electro-Dynamic Machines. (Provisional.)

Describes making the core of the revolving armature barrel shaped, with radial projecting fins forming channels for the reception of the wire. Various methods of winding the wire along the channels are described according to the number of fields embracing it. (*See* also Machines—Lontin type.)

1880. **W. R. LAKE.** 3928.

(From E. THOMSON.)

Improvements in Apparatus for the Generation of Electric Currents.

Describes a machine where the revolving armature coils are wound so that all parts shall be at all times under the direct influence of the field magnets.

Also describes a form of exiting or field electro-magnet which shall utilise both the internal and external magnetising effects.

1881. **GÜMPEL.** 253.

See Machines—Lontin type.

1881. R. WALLER. 803.

Improvements in Dynamic Apparatus and Motors, in Batteries in connection therewith, and in Carbons for obtaining Electric Light.

Describes a machine with the revolving armature coils wound round an annular iron core, broad in section. The coils are embraced by and ortate between extended poles of field electro-magnets constructed on the "Altande" form.

Also describes the use of several separate sets of revolving armatures.

Also describes electrodes for arc lamps made in the form of a spiral. A lamp is illustrated for burning the above carbons, which are brought together by means of cords wound round a shaft, with weights attached to the ends of the cords.

1881. J. H. JOHNSON. 5551.

(From W. W. Griscom.)

Improvements in Armatures for Magneto-Electric and Dynamo-Electric Machines and Motors.

Describes the use of an armature of type known as Siemens', with a projecting piece of metal on the iron faces or sides.

IV.—OF THE LONTIN TYPE.

1878. BRAIN. 5139.

See Machines—Gramme type.

1879. J. D. F. ANDREWS. 2321.

Improvements in Apparatus for the Production and Regulation of Electricity applied for Illumination.

Describes a machine where the armature coils consist of long iron cores wound lengthwise with wire, the inducing electro-magnets surrounding the revolving coils, and consisting of an iron framework wound with wire from each end so that the poles shall be concentrated on each side of armature.

Describes an electric lamp where two flat plates of carbon placed side by side are used.

Also uses two circular plates of carbon, the arc being formed at periphery.

1879. LAKE. 4400.

See Machines—Gramme type.

1879. JOEL. 5157.

See Lamps, Arc—Vertical Carbons.

1880. F. G. WILLATT. 3808.

Improvements in Dynamo-Machines.—(Provisional.)

Describes a machine with revolving armature consisting of an iron core

cast in one piece, with radial blades broad at the outer ends and narrow towards the centre, wound with wire. On opposite sides of the armature are projecting poles of the field electro-magnets.

1881. W. R. LAKE. 48.

(From E. ETÈVE.)

Improvements in Apparatus for Generating and Utilising Electricity for Lighting or other purposes.

Describes a machine where the revolving armature coil rotates between iron polar extensions of a permanent magnet. The core of the armature is at right angles to axis of rotation, the arms of the permanent magnet being provided with coils of wire.

1881. G. GÜMPEL. 253.

Improvements in Apparatus for Producing Electric Currents and Applying them to Illumination, etc.

Describes various forms of revolving armatures, one of which consists of electro-magnet coils mounted on a barrel-shaped base fixed to the axle of machine, the coils radiating from this base at various angles according to the position of the coil on the base. Another form of revolving armature consists of a barrel-shaped core which is provided with channels placed lengthwise along the periphery of same. The wire coils are wound in these channels as follows:—The wire of one coil is wound round No. 1 channel, then it returns by No. 6 channel; another coil of wire is wound round No. 6 channel and returns by No. 11 channel; another coil is wound round 11th channel to the 1st again; other coils are wound in the same way from 2 to 7, 7 to 12, and so on, until the whole of the channels are filled with wire. Several forms of field magnets are described. In the first one described 2 permanent magnets are used with the 4 poles, embracing periphery of armature coils; another form is described where electro-magnets are used, with the four projecting poles embracing the armature; in another form described double electro-magnet coils are used. Here the extended pole-pieces from one set of coils are joined to the extended poles of another set of coils, the armature revolving between the extended poles.

1881. F. M. NEWTON. 4559.

Improvements in Apparatus for Generating and Utilising Electricity.

Describes a machine with armature revolving coils wound on a longitudinal drum, with metal pieces projecting radially and forming divisions in which the coils are wound. There are 16 divisions, one coil being wound in the 1st and 6th divisions, another from 9 to 14, another from 2 to 13, and another from 5 to 10, and so on until the whole of the divisions are filled with its half of a coil.

1881. J. RICHARDSON. 5681.

Improvements in the Construction and Arrangement of Dynamo-Electric Machines.

Describes a machine with revolving electro-magnet armature coils placed

at right angles to each other, and which are embraced in polar extensions of the field electro-magnets.

1882. H. E. NEWTON. 943.

(From A. T. Gravier.)

Improved Machinery for Obtaining Continuous or Alternating Currents of Electricity.

Describes a machine with armature revolving electro-magnet coils placed radially from the axle of machine; outside and surrounding the armature coils are the field magnet coils which consists of an annular core of iron wound with two coils of wire.

1882. W. H. AKESTER and T. B. BARNES. 986.

Improvements in Dynamo-Electric Machines.

Describes a machine with two compound rotating armatures. Each set of armature electro-magnet coils consists of coils of wire wound on iron cores, with outer covers or cases of iron, and placed radially from the axle of machine; four circles of coils compose each compound armature, and are arranged spirally round the shaft. Two broad single field electro-magnets are placed between each set of armature coils, the polar extension of each electro-magnet embracing one-half of each set of armature coils, and are arranged so that the poles opposite are of opposite polarity.

V.—MISCELLANEOUS.

1878. H. C. SPALDING. 1467.

Improvements in the Method of Originating and Developing Electric Currents.

(Provisional.)

Describes method of bringing into simultaneous action a series of dynamo-electric machines, so arranged and connected that a current of electricity produced in one shall be conducted in turn to the next machine, whereby a feeble current produced in the first may be increased or intensified by successively passing through the remaining machines of the series.

1878. T. A. EDISON. 4226.

Improvements in the Method of and Means for Developing Electric Currents and Lighting by Electricity.

Uses a generator in the form of a large tuning-fork, the free ends being vibrated by mechanical force; electro-magnets are fixed to the end of the forks, opposite which are two other electro-magnets.

Also describes light produced by rendering incandescent a spiral coil of wire, or a leaf or strip of metal or carbon or other material.

1878. C. DAVIS. **4559.**

Improvement in the Arrangement of Mechanism, &c., for Producing Light by means of Electricity.—(Provisional.)

Describes method of driving a dynamo by means of cog-wheels or pulleys attached to the wheels of carriages.

1878. F. M. C. VOGEL. **4812.**

Improvements in Machinery for Generating Electricity.—(Provisional.)

Describes method of revolving the armature in one direction, and the field electro-magnets in the opposite direction.

1878. S. P. THOMSON and W. P. THOMSON. **4938.**

Improvements in or appertaining to Apparatus for Producing or Concentrating Electricity, and in the Production of Electric Light or Compound Electric and Combustion Light.—(Provisional.)

Describes using German silver wire on armature revolving coils of dynamo machines, instead of copper.

1878. T. A. EDISON. **5306.**

Improvements in Means for Developing Magnetism and Electric Currents and in Apparatus for Illuminating by Electricity.

Describes a machine which is arranged for the induced magnetism to react on a permanent magnet and increase its power.

Also uses copper rings or segments rotating between magnetic poles.

Also describes method of rendering incandescent a strip of platinum coiled into a spiral, and coated with a pyro-insulating material formed of an oxide or other compound, or asbestos.

1879. J. RAPIEFF. **211.**

Improvements in the Means of Producing and Applying Electric Currents, etc.

Describes method of using for cores of electro-magnets in dynamo machines a diamagnetic material to lessen the absorption of magnetism.

Also describes a lamp with the carbons placed at an angle with their ends resting on a refractory material.

1879. J. F. WILES. **644.**

Improvements in Magneto-Electric or Dynamo-Electric Machines.

Describes an armature rotating in one direction and the field electro-magnets in the opposite direction.

1879. A. W. LAKE. **1387.**

(From N. S. KEITH.)

Improvements in Dynamo- and Magneto-Electric Machines, etc.—(Provisional.)

The space between the poles of the field electro-magnets are made of a special shape, the revolving armature coils having an iron core.

Also describes a lamp with vertical carbons, both carbons moveable. The lower carbon is raised by means of cords by the weight of the top carbon-holder the cords pass over drums placed one on each side of a serrated wheel, the regulation being effected by means of a lever, attached to which is an armature operated by an electro-magnet.

1879. C. W. SIEMENS. **4534.**

Improvements in Dynamo-Electric and Electro-Dynamic Machines.

Describes method of connecting in a branch circuit complete in itself, and independently of the external circuit, the armature and the electro-magnet coils.

1880. J. GRADDON. **885.**

Improvements in Machinery for Producing Motive Power and Light by means of Electricity.—(Provisional.)

The description of this patent is not readily understood, but it describes generating electricity by rotating a magnetic material in the vicinity of wires, etc.

Also describes combining gas and electricity to produce light.

1880. C. W. HARRISON. **886.**

Improvements in Apparatus for Obtaining Electricity.—(Provisional.)

Electric currents are produced by vibrating or moving metallic bars inside coils or helices of wire.

1880. J. H. JOHNSON. **1136.**
(From A. DE MERITENS.)

Improvements in Magneto-Electric and Dynamo-Electric Machines.

Describes an arrangement whereby the connections of a dynamo machine are in combination with a commutator, to excite the field magnets of an alternating current machine without the aid of special auxiliary coils.

1880. T. A. EDISON. **1385.**

Improvements in Dynamo- or Magneto-Electric Machines and Electric Motors.

Iron core of the revolving armature coils is made of very thin discs or ring; the brushes are placed obliquely on the commutator, to avoid sparking.

1880. P. JENSEN. **3964.**
(From T. A. EDISON.)

Improvements in Magneto- or Dynamo-Electric Machines, applicable to both Generators and Engines.

Describes a new arrangement of commutator brushes, whereby a number of brushes are used, instead of one large brush, to lead the current from the commutator of machine, so that either of these brushes can be replaced by others without stopping or interfering with the working of the machine.

Also describes other improvements in his machine, as described in a previous patent.

1881. E. G. BREWER. 1240.

(From T. A. EDISON.)

Improvements in Armatures for Dynamo, etc.

Describes a revolving armature, whereby the coils consist of wire or naked bars of copper, and are placed side by side between discs. An arrangement is described whereby any number of these coils can be connected together on the periphery of the armature by means of metallic bars and the discs.

1881. C. A. BARLOW. 2212.

(From A. DE MERITENS.)

Improvements in Dynamo-Electric Machines.—(Provisional.)

Describes the use of an armature ring revolving between the poles and extremities of two clusters of horse-shoe magnets.

1881. P. JENSEN. 2954.

(From T. A. EDISON.)

Improvements in Magneto- or Dynamo-Electric Machines or Electric Engines.

Describes a machine with the armature, consisting of radial bars of metal, revolving between four polar extensions of powerful field electro-magnets.

1881. A. M. CLARK. 3169.

(From W. LANG.)

Improvements in Dynamo- and Magneto-Electric Machines.

Describes method of working, a make or break or the commutator of the machine in water or fluid of no conductivity.

1881. E. G. BREWER. 3231.

(From T. A. EDISON.)

Improvements in Commutators for Magneto- or Dynamo-Electric Machines or Motors.

Describes the use of a number of separate connection brushes rubbing on the commutator, instead of one large brush, so that when the brushes are taken off the current is split up into several parts from each brush respectively.

1881. S. PITT. 3283.

(From S. J. M. BEAR.)

Improvements in Electric Generators.

Describes a machine where the extended iron poles of the armatures revolve in contact with the poles of the field magnet.

1881. P. JENSEN. 3804.

(From T. A. EDISON.)

Improvements in Commutators for Dynamo, etc.

Describes method of amalgamating the commutator strips on machine.

1881. P. JENSEN. **3932.**

(From T. A. Edison.)

Improvements in Dynamo- or Magneto-Electric Machines.

Describes use of inductive bars running lengthwise of the armatures.

1881. P. JENSEN. **4552.**

(From T. A. Edison.)

Improvements in Dynamo- or Magneto-Electric Machines.

Describes a means of regulating the generative force of an electric generator by diminishing or increasing the mass of metal which joins the ends of the field electro-magnets.

1881. H. J. HADDAN and G. DESSAIGNE. **4591.**

Improvements in the Mode of Generating Electricity.—(Provisional.)

Utilising power of machines by placing magnets on their fly-wheels, and placing bobbins round the magnets.

1881. S. A. VARLEY. **5667.**

Improvements in Means and Apparatus for the Collection and Distribution of Electric Currents.

Describes method of using, instead of the brushes usually employed in the commutators of dynamo-electric machines, a combination of revolving wheels or discs with projections.

1881. Sir W. THOMSON. **5668.**

Improvements in Dynamo-Electric Machines, etc.

Describes a machine with the revolving armature consisting of radial bars of copper.

Describes, also, the use of an armature of copper slip wound in a zig-zag manner round wooden pins projecting from the side of periphery of a circular disc. The armature is moved between the poles of a field magnet of circular form which is placed outside the armature; another electro-magnet is placed inside the armature coils, the poles of which are opposite the poles of the outer electro-magnet.

1882. H. S. RAISON. **169.**

Improvments in Electro-Motors and Dynamo-Electric Machines, etc.

Describes a machine where the armature rotates in one direction and the field magnets in the other. The coils are placed on an iron core placed at right angles to axle of machine, the wire being wound so that it shall have a globular form on outside.

1882. C. J. GRUBB. **761.**

Improvements in Dynamo-Electric and Magneto-Electric Machines.—(Provisional.)

Describes method of revolving the armature in one direction, and the field electro-magnets in the opposite direction.

882. **W. R. LAKE.** 2526.

(From J. J. Wood.)

Improvements in Dynamo- or Magneto-Electric Machines.

Describes a means for shifting the brushes on dynamo-electric machines.

1882. **W. R. LAKE.** 2623.

(From J. J. Wood.)

Improvements in Devices for Coupling or Connecting the Armatures and Commutators of Magneto- or Dynamo-Electric Machines.

Describes a new form of commutator, and a means of attaching the wires from the armature coils thereto.

SUBDIVISION II.

LAMPS.

ARC.

I. CARBONS PLACED AT AN ANGLE, WITH THE APEX DOWNWARD, thus V.

1878. **J. S. SELLON, W. LADD, and H. EDMUNDS.** 4646.

Improvements in Electric Lamps.

Describes a lamp having carbons set at an angle, or they may be parallel; the ends of the carbon electrodes resting on a heat-resisting metal, such as iridium.

1879. **RAPIEFF.** 211.

See Machines—Miscellaneous.

1879. **ANDRÉ.** 830.

See Semi-Incandescent.

1880. **A. M. CLARK and J. M. A. GÉRARD LESCUYER.** 1552.

Improvements in Electric Lamps.

In this lamp the carbons are are held in tubes, and are allowed to descend by their own weight. The arc is formed by means of an electro-magnet, the armature of which is attached to the tubes holding the carbons.

1880. **K. W. HEDGES.** 4988.

Improvements in Electric Lamps.

Describes an electric lamp with inclined carbons, without resting on a refractory substance.

Also uses a third carbon butting against the end of one of the inclined carbons.

1882. **W. T. HENLEY.** 130.

Improvements in Machinery and Apparatus for Obtaining, Transmitting, and Applying Electric Currents, etc.

In this lamp the carbons are controlled by clockwork and a weight. The arc is formed by means of two armatures which are attached to the carbon-holder tubes, and which are attracted by an electro-magnet fixed to the top of the lamp.

1882. **SPAGNOLETTI.** 869.

See Machines—Wilde Type.

1878. **SIEMENS.** 3134.
1879. **HEDGES.** 81.
1879. **HEDGES.** 925.
1880. **HADDAN.** 1704.
1881. **JACHS.** 894.
1881. **ROGERS.** 1922.

See Carbons Combined with Non-Conductors.

1881. **CLARK.** 1685.

See Lamps, Arc—Vertical Carbons.

1882. **GRAHAM.** 1171.

See Lamps, Arc—Vertical Carbons.

II. CARBONS PLACED AT AN ANGLE, WITH THE APEX UPWARD, thus $\wedge$.

1878. **HICKLEY.** 4132.

See Electrodes for Incandescent Lamps.

1878. **J. S. WILSON.** 4347.

Improvements in and appertaining to Apparatus for Producing Electric Light.

Describes a lamp with the carbon placed at an angle. One holder is fixed, the other is moveable. The arc is formed by one holder being pulled on one side by means of an armature opposite the poles of an electro-magnet.

1880. W. L. WISE. 4914.

(From J. M. Mandon.)

Improvements in Electric Light Apparatus.

Describes a lamp where the two carbons are each in the form of a quadrant, and are kept with upper extremities in a proper position by means of a counterweight.

Also describes a lamp where the carbons are raised by a float in mercury.

1879. BROWN. 144.

1881. CLARK. 3214.

1881. TUBINI. 3822.

See No. 7—Carbons combined with Non-Conductors.

1882. GRAHAM. 1171.

See Lamps, Arc—Vertical Carbons.

III. PARALLEL VERTICAL CARBONS, thus ||

1878. H. WILDE. 3250.

Improvements in Producing and Regulating Electric Light.

Describes a lamp having one carbon fixed and the other attached to a holder fixed to an armature which is opposite an electro-magnet. When the lamp is not in use the carbons touch at their upper extremities, but when the current is passed through the lamp one of the carbons is pulled by means of its holder away from contact, and the are is formed.

1878. J. MACKENZIE. 4568.

Improvements in Electric Light Apparatus.—(Provisional).

Describes lamp with carbons placed in tubes containing mercury.

1879. A. DE MERITENS. 178.

Improved Means for Obtaining Light by Electricity.—(Provisional).

Describes a form of candle where the rods of carbon are placed vertically, and parallel to each other, having an insulated strip of carbon between them.

1879. A. M. CLARK. 2339.

(From A. De Meritens & Co.)

Improved Means for Obtaining Light by Electricity.

Describes a multiple carbon burner where the arc is formed across the tops of a number of carbon rods or pencils.

1880. C. D. ABEL. 1553.

(From Compagnie Générale d'Éclairage Électrique de Paris.)

Improvements in Electric Lamps.

Describes an improved arrangement for separating the points of carbons placed side by side.

IV. VERTICAL CARBONS, thus |

1878. C. W. SIEMENS. 2281.

Improved Means and Apparatus for Distributing and Regulating Electric Currents to Work Lamps and other Electric Apparatus.

In this lamp both carbons are moveable. The lower carbon is attached to a holder which is fixed to an arm carried by the armature of an electro-magnet. The electro-magnet and frame and carbon-holder are carried by a rod with a rack cut on one side, into which gears a pinion which is made to move by the weight of the upper carbon rod, having a weight attached. The carbons do not touch when the lamp is not burning, but are brought into contact when the current is put on to form the arc by means of the armature of the electro-magnet.

Also describes regulating the current by the expansion by heat of a metal strip passing over studs, thereby placing resistance in circuit.

1878. A. LONGSDON. 3837.

Improvements in Electric Light Apparatus.

The carbons of this lamp are regulated by means of mechanism controlled by a fan revolving in mercury, and stopped by means of an armature acting on a brake wheel.

1878. G. P. HARDING. 4046.

Improvements in Obtaining Light.—(Provisional.)

The carbons are regulated by the weight of the electrodes supported by columns of fluid maintained by a constant head.

1878. G. P. HARDING. 4047.

Improvements in Apparatus for Regulating Electric Light.

Describes the use of a wire which is made to expand by the heat of the arc, to make contact, and place a shunt in circuit, thereby diverting a part of the current.

1878. A. REIMENSCHNEIDER and F. S. CHRISTENSEN. 4693.

Improvements in the Method of Dividing Electric Light and Apparatus therefor. (Provisional.)

Describes a lamp with vertical electrodes consisting of graphite, carbon, or platinum, and contained in a vacuum or in a space almost entirely void of air.

1878. **R. SABINE.** 4821.

Improvements in Electric Lamps or Regulators.—(Provisional.)

Describes the use of the heated air from the arc to drive a fan, and thereby regulate the feed of the carbons.

1878. **C. W. SIEMENS.** 4949.

(From Hefner von Alteneck.)

Improvements in Electric Lamps.

Describes a form of lamp having two flat plates inclined at an acute angle, their flat sides being presented towards each other; one carbon is fixed, and the other is attached to the armature of an electro-magnet, which separates the carbons when the current passes through it.

Another form of lamp described consists of two carbon rods placed in a vertical position; the lower carbon is fixed. The upper carbon is moveable, its downward motion being checked by a ratchet-wheel and pawl arrangement; the pawls are released from the teeth of the wheel by means of a lever attached to an iron core which moves in a solenoid.

Also describes a lamp with vertical carbons, the feed of the carbons being regulated by the movement of a pendulum which is connected by wheels to the carbon rods; an iron core working in a solenoid secures and releases the movement of the pendulum.

1878. **A. V. NEWTON.** 5060.

(From De Mersanne.)

Improvements in Electric Light Regulators.

Describes a lamp, which can be used for burning long carbons either vertically or horizontally, consisting of a train of wheels worked by means of a spring which gives motion through suitable gearing to guide rollers, between which the carbon rods pass.

1878. **J. H. JOHNSON.** 5110.

(From De Mersanne.)

Improvements in Regulators for Electric Light.

Describes improvements in the lamp described in previous specification, No. 5060, 1878.

1879. **B. A. RAWORTH.** 27.

Improvements in Apparatus for Producing Electric Light.

Describes the insertion of resistances of mercury to regulate strength of current.

Also describes a lamp with vertical carbons, the regulating mechanism being controlled by means of a copper disc attached to the wheels, revolving opposite or between the poles of an electro-magnet.

1879. **W. LADD.** 83.

(From J. JASPER.)

Improvements in Electric Lamps.

In this lamp the carbons are arranged to approach each other by means of cords attached to the holders, weights being fastened to the other end of the cords.

1879. **E. T. BOUSFIELD and W. R. BOUSFIELD.** 523.

Improved Apparatus for Obtaining Electric Currents, etc.

In this machine the revolving armature coils are wound round an annular core, and rotate between the two polar extensions of field electro-magnets.

A lamp is also described, having vertical carbons, the bottom carbon being fixed; the upper carbon slides in a groove, with a spring pressing on one side; when the tension of the spring is taken off by an electro-magnet, the carbon is allowed to slide past it.

Also describes a lamp in which the carbons are made to approach each other by means of cords attached to the holders, and passing over pulleys, weights being attached to the other end of the cords. The feed is regulated by means of mechanisms controlled by a wheel having a number of iron armatures fixed to it, and rotates in front of the poles of an electro-magnet.

1879. **H. J. HADDAN.** 947.

(From C. F. BRUSH.)

Improvements in Apparatus for Electric Lighting.

In this lamp the bottom carbon is fixed, the upper carbon being attached to a rod which passes through a ring of metal, which is raised on one side by means of an armature opposite the poles of an electro-magnet, thereby securing the rod.

Also describes an automatic shunt for use with lamp.

1879. **LAKE.** 1387.

See Machines—Miscellaneous.

1879. **J. MACKENZIE.** 1635.

Improvements in Electric Light Apparatus.

Describes a form of clutch lamp where the end of a lever presses against the top carbon, and prevents it from falling. The bottom carbon is raised by a spiral screw actuated by a ratchet-wheel and an electro-magnet.

1879. **A. LONGSDON.** 1969.

(From A. KRUPP.)

Improvements in and connected with Electric Light Apparatus and Lamps.

Describes a lamp with vertical carbons, the bottom one being fixed except when the arc is to be formed; the upper carbon is attached to a rod which is held by means of a clutch lever pressing on one side.

1879. J. COUGNET. 2000.

Improvement in Electric Lamps.—(Provisional.)

In this lamp the bottom carbon is moveable and made the positive electrode. The carbon is raised by means of a cord to the end of which is attached a weight; the cord passes round a friction wheel which is kept from moving by a lever to which is fixed an armature opposite the poles of an electro-magnet. The bottom carbon is contained in a tube, the end of which is made of platinum and through which the carbon passes at its taper end. The upper or negative electrode consists of a carbon plate or disc which is secured to a suitable frame by a set nut.

1879. C. D. ABEL. 2322.

From H. Sedlaczek and F. Wicknhill.—(Provisional.)

In this lamp both carbons are moveable. The carbons are attached to rods, to the ends of which are pistons working in tubes containing liquid. The tubes are in communication one with the other, the flow of the liquid being regulated by means of a tap or cock provided for that purpose, and which is connected to and operated by an armature working opposite the poles of an electro-magnet.

1879. C. W. SIEMENS. 2652.

(From F. von H. Alteneck.)

Improvements in Electric Lamps.

In this lamp the feed of the carbons is regulated by the movement of a pendulum, the motion of which is stopped by means of an iron core working in two coils of wire; one coil being in the main circuit, and the other in a shunt circuit with the carbons.

1879. B. J. B. MILLS. 3085.

(From F. Million.)

Improvements in Regulators for the Electric Light.

Describes method of regulating arc lamps with vertical carbon rods, by means of racks and pinions actuated by a pendulum rod with a pawl. Attached to the end of this rod is an iron armature or core which oscillates or passes from one core or electro-magnet to another.

1879. R. E. B. CROMPTON. 3509.

Improvements in Regulating Mechanism for Electric Lamps.

Describes a lamp with vertical carbons, the feed of the carbons being regulated by a train of wheels and electro-magnets.

1879. H. J. HADDAN. 3750.

(From C. F. Brush.)

Improvements in Electric Lamps and Mechanism for Electric Lighting.

Describes a lamp with vertical carbons, the bottom carbon being fixed.

The upper carbon is attached to a rod around which is placed a ring of metal which is raised on one side and secures the rod.

1879. J. BROCKIE. 3771.

Improvements in Electric Lamps.

Describes a lamp with vertical carbons, the carbons being fed periodically by means of an automatic commutator.

1879. LAKE. 4400.

See Machines—Gramme type.

1879. S. PITT. 5156.

(From C. E. SCRIBNER.)

Improvements in Electric Light Regulators.

In this lamp the bottom carbon is fixed; the upper carbon is held at the end of a metal rod, around which, and attached to the armature of an electro-magnet, is a spring metal clip having sufficient tension to hold the rod. An electro-magnet opposite this armature in the main circuit attracts the armature, and lifts with it the rod. When a feed of the carbons is required, it brings into action an electro-magnet in shunt circuit. The armature of this electro-magnet carries a clutching device which presses against the rod and prevents the rod being raised again when the electro-magnet in main circuit attracts its armature.

1879. H. F. JOEL. 5157.

Improvements in Magneto-Electric Machines and Electric Light Apparatus.

Describes a machine with the armature revolving. Electro-magnet coils radiate from the shaft of machine, and rotate opposite the poles of the field electro-magnets which surround the armature coils.

Also describes a lamp with a carbon rod made to rise, by means of cords and weights, and press against a carbon or metallic block, as in the Werdermann lamp.

Also describes a lamp with vertical carbons, the bottom carbon being fixed; the upper carbon is attached to a holder, which is held by two clutches, one on each side of the top carbon rod.

1880. LAKE. 315.

See Machines—Siemens type.

1880. G. W. WIGNER. 553.

Improved Regulators or Lamps for the Electric Light.

Describes a form of lamp with vertical carbons, both carbons being moveable. The bottom carbon is raised by means of a float resting on the surface of water contained in a vessel; the upper carbon is allowed to move down by means of cords passing over pulleys and attached to the float of bottom carbon rod. The arc is formed by means of the armature of an electro-magnet being attracted by an electro-magnet attached to the piston connected with the float.

1880. **CLARK.** 842.

See Carbons combined with Non-Conductors.

1880. **C. D. ABEL.** 1397.

(From F. KRIZIK and L. PIETTE.)

Improvements in Electric Lamps and in Solenoids applicable for their Regulation.

In this lamp both carbons are moveable, the bottom one being raised by means of cords passing over pulleys by the weight of the upper carbon-holder; the upper carbon-holder is held by means of a clutch pressing on one side of same. The regulation is effected by the differential action of two solenoids of wire acting on an iron core contained within the coils.

1880. **MAXIM.** 1649.

See Lamps—Incandescent in Vacuum.

1880. **S. COHNÉ.** 2236.

A New and Improved Electric Lamp, etc.—(Provisional.)

In this lamp both carbons are moveable, the lower carbon being raised by means of a float submerged in water or other fluid, and its upward movement is regulated by an armature opposite the poles of an electro-magnet. The upper carbon is allowed to descend by being secured to a holder which is made to move by a rack and pinion arrangement contained in a rectangular frame on each side of the lamp; the motion is obtained from the float operating the bottom carbon.

1880. **G. P. HARDING.** 4191.

Improvement in Electric Lamps.

Describes a form of clutch lamp where the the top carbon rod is secured and raised by two eccentric cams, one on each side of carbon-holder rod, the lower carbon being fixed.

1880. **HEINRICHS.** 4608.

See Machines—Gramme type.

1880. **W. R. LAKE.** 4866.

(From H. S. MAXIM.)

Improvements in Electric Lighting Apparatus.

Describes a form of lamp where the top carbon is held by a gravitation carrier, and regulated by means of a train of gearing, being alternately released and stopped by a detent engaging with the gearing.

1881. **A. MUIRHEAD and J. HOPKINSON.** 153.

Improvements in Electric Lamps.

Describes a lamp with vertical carbons, the bottom carbon being fixed except when the arc is to be formed, when it is pulled down by the armature

of an electro-magnet. The top carbon is allowed to feed by the descent of a screw to the end of which the carbon is attached; the screw gives a rotary movement to the carbons.

1881. C. G. GÜMPEL. **253.**

Improvements in Apparatus for Producing Electric Currents and Applying them to Illumination, etc.

Describes a form of lamp, the bottom carbon of which is fixed. The upper carbon is attached to a rod which has teeth cut on one side; these teeth gear into a pinion to which is attached a ratchet-wheel opposite the teeth of which is a pawl with several teeth, and arranged to engage in the teeth of the ratchet-wheel. When the armature is attracted by an electro-magnet the armature lever raises the frame which carries the wheels and rod, and thereby forms the arc. When the carbons require adjusting after burning away, the armature leaves the electro-magnet and allows the frame to descend, and the pawl engages with the teeth on the ratchet-wheel, and thus allows the top carbon rod to move downward. In another lamp a brake-wheel is substituted for the ratchet-wheel.

1881. J. FYFE. **774.**

Improvements in Electric Lamps.—(Provisional.)

Describes a form of lamp with guide rollers attached to the cross arms holding the top and bottom carbons, moving between two rods insulated from each other. On the top of the lamp is a pulley to which is attached a cord which passes to the bottom of a lamp post, where an arrangement with differential coils, etc., is placed to regulate the feed of the carbon rod.

1881. A. A. COMMON and H. F. JOEL. **1040.**

Improvements in Electric Lamps.

Describes an arc lamp with the bottom carbon fixed; the top carbon is attached to a rod which has a rack on one side gearing into a pinion to which is attached a disc or brake-wheel. A gripping lever is attached to the iron core working in a solenoid, which pulls the lever, when the current passes and grips the disc, giving an upward movement to the rod and thereby forming the arc.

Improvements in the Werdermann lamp are described, and consist chiefly of a means for maintaining the carbon in contact with the metal pole.

1881. W. R. LAKE. **1384.**

(From A. G. Holcombe.)

Improvements in Electric Lighting Apparatus.

Describes a lamp with the bottom carbon attached to a holder fixed to a moving coil, and moved only when the arc is to be formed. The upper carbon is attached to a rod which has a rack on one side gearing into a pinion, attached to a wheel with teeth which gears into another pinion, to which is

attached a brake-wheel; two flat coils facing each other are used to actuate the brake-wheels.

1881. J. D. F. ANDREWS. 1526.

Improvements in Electric Lamps.

Describes a form of lamp with two flat plates of carbon placed side by side. Also describes a lamp with two circular plates of carbon, one plate placed above the other. Another form of lamp is described where the feed of the top carbon is regulated by a clutch in the form of a U gripping the rod.

1881. A. W. L. REDDIE. 1596.

(From H. SEDLACZEK and FRANZ WIKNLILL.)

Improvements in Electric Lamps.

Describes a form of lamp where both carbons are regulated by the passage of fluid from vessels connected to each electrode. Pistons contained in tubes with the fluids, acting on them, regulate the feed of the carbons.

1881. G. S. GRIMSTON. 1670.

Improvements in Electric Lamps.

Describes a lamp regulated by the differential action of two solenoids, and actuating a lever and clutch which grips a tube attached to the upper carbon. The tube is filled with glycerine, and the weight of the tube and carbon moves it downward, except when it is stopped by the clutch.

1881. A. M. CLARK. 1685.

(From J. M. GERARD LESCUYER.)

Improvements in Electric Lamps or Regulators.

Describes a form of lamp where the bottom carbon is fixed, and the top carbon is regulated and carried by an electro-magnet arranged to slide down a guide as the carbons are consumed; the armature of the electro-magnet regulates the downward movement of the electro-magnet.

Another form of lamp is shown where the carbons are placed at an angle, the apex of the angle of the carbons being at the bottom. The carbons are contained in guide tubes, and are regulated by an electro-magnet arrangement precisely similar to the vertical carbon lamp, a cross arm attached to the electro-magnet carrying the two carbon-holders; the arc is formed by an upper armature raising and separating the carbons.

1881. J. BROCKIE. 1942.

Improvements in Electric Arc Lamps.

In this lamp the bottom carbon is attached to a holder fastened to an arm in connection with the core of a solenoid, and is used to form the arc. The upper carbon is secured to a rod against which rests a clutch attached o a lever actuated by the core of a solenoid, also by an electro-magnet coil.

1881. H. J. HADDEN. 2038.

(From R. J. GULCHER.)

Improvements in Electric Light Apparatus.

Describes a form of lamp with vertical carbons, both carbons being moveable. The bottom carbon is raised by means of the weight of the upper carbon rod. The upper carbon is held by a cross arm attached to a rod which is made of iron in its whole length and moves in its descent in front of the end of an electro-magnet coil. This electro-magnet coil is made to oscillate about a centre somewhat nearer one end of the coil than the other. The opposite end of the oscillating electro-magnet coil is provided with a pole-piece which extends at right angles to the end of the coil and below the same. Opposite this iron pole-piece is a piece of soft iron fixed to the frame of lamp, the object of which is to allow the electro-magnet coil to be attracted to the fixed piece of iron, and at the same time to attract or hold and raise the top carbon rod, thereby forming the arc. As the carbons burn away and the magnetism in the coil becomes weakened, the top carbon rod slides past the end of the electro-magnet coil until it is arrested by increased magnetism.

1881. C. D. ABEL. 2198.

(From H. KLEIBER.)

Improvements in Electric Lamps.

Describes the use of two small motors to regulate the feed of the carbons. The upper carbon is attached to a rod having a rack cut on one side, which gears a pinion made to move by means of an endless screw attached to the spindle of armature of motor. One motor is wound with thick, and the other with fine wire.

1881. S. COHNÉ. 2369.

A New and Improved Electric Lamp with Automatic Regulation, etc.

Describes a form of lamp with vertical carbons, in which both carbons are moveable. The bottom carbon is raised by means of a float in a vessel or cylinder containing glycerine or other fluid. To the cross arm attached to the bottom carbon-holder is fixed a rack, which, when raised, gears into a pinion on the opposite side of which is another rack, and thereby allows the descent of the upper carbon. The movement is regulated by the armature of an electro-magnet preventing the piston-rod from moving.

1881. G. HANKES and R. BOWMAN. 2402.

Improvements in Electric Lamps.

In this lamp the upper carbon is attached to a holder which is secured to the armature of an electro-magnet, and is used to form the arc. The lower carbon is attached to a holder which is fixed to a piston-rod at the end of which is a leather piston. The upward movement of the rod is stopped by a gripping-piece attached to the armature of an electro-magnet.

1881. **E. G. BREWER.** 2495.

(From T. A. Edison.)

Improvements in Electric Arc Lights.

Describes a lamp with vertical carbons, the bottom one being fixed; the top one is attached to the end of a rod which is made to rotate very rapidly by means of an armature, and which is attached to the rod moving in front of an electro-magnet. The regulation of the lamp is effected by means of two clutches placed one on each side of the rod holding the top carbon.

1881. **G. G. ANDRÉ.** 2563.

Improvements in Electric Lamps.

Describes a lamp with vertical carbons, where the bottom carbon is fixed; the top carbon is secured to the end of an iron rod, which is held up by friction against the pole-pieces of one or more electro-magnets. The rod is allowed to slide past the pole-pieces, when the friction due to magnetic attraction becomes lessened.

1881. **W. R. LAKE.** 2851.

(From J. J. Wood.)

Improvements in Electric Lighting Apparatus.

Describes a form of arc lamp where the bottom carbon is fixed; the top carbon is regulated by means of train of wheels actuated by a lever attached to the core of a double solenoid.

1881. **W. R. LAKE.** 3015.

(From J. J. C. W. Greb.)

Improvements in Electric Lighting Apparatus, etc.—(Provisional.)

Describes a lamp with vertical carbons, both carbons being moveable. The regulation is effected by means of an armature of an electro-magnet operating two pawls in connection with ratchet-wheels to which are fixed pulleys over which cords pass to the carbon-holders.

1881. **F. W. HADDAN.** 3049.

(From L. G. Woolley.)

Improvements in Electric Lamps.

Describes a form of lamp with the bottom carbon fixed; the upper carbon is secured to the end of a tube containing glycerine. Inside the tube is the piston and piston-rod, which are attached to the core within a solenoid. The arc is formed by the core within the solenoid being drawn upwards; at the same time a small lever which is connected to the end of the piston-rod is canted on one side and grips the tube.

1881. **W. M. BROWN.** 3166.

(From G. P. Harding.)

Improvements in Electric Lamps.

In this lamp the bottom carbon is fixed, the top carbon being attached to

a holder to the end of which is a cord; this cord passes round a drum on the shaft of which is an escapement wheel, the pallets being worked by an electro-magnet which regulates the burning of the carbons. The recoil of the escapement separates the carbons and forms the arc at starting.

Another lamp is described where a kind of double clutch is used, consisting of two springs, one on each side of the rod, which are drawn upwards by an electro-magnet, and are made to grip the rod by being made taper on outside and drawn between a metal shoulder.

1881 **CLARK.** 3214.

See Machines—Gramme type.

1881. **C. T. BRIGHT.** 3305.

Improvements in Apparatus for Displaying and Regulating Electric Light. (Provisional.)

Describes a lamp with vertical carbons and relay arrangement for regulating same. The relay closes a circuit, which causes an electro-magnet to regulate the feed of the carbons. The arc is formed by another electro-magnet.

1881. **A. W. L. REDDIE.** 3349.

(From D. A. Chertemps.)

Improvements in Electric Lamps.

Describes an arc lamp where the bottom carbon is separated from the top carbon by means of an iron core moving in a solenoid. The upper carbon is attached to a rod which has a rack on one side and gears into clockwork mechanism; the clockwork is stopped by means of a pin which projects from the side of the bottom carbon-holder.

1881. **J. HOPKINSON.** 3362.

Improvements in Electric Lamps, etc.

Describes a form of arc lamp where the bottom carbon is fixed; the top carbon is regulated by means of a piston moving in a cylinder containing glycerine. The piston-rod is secured and held by the end of a lever resting on the side. The carbons are separated by means of an electro-magnet raising the glycerine-holder.

Also describes the iron core of a revolving armature coil made of coiled ribbon of sheet-iron.

1881. **MOFFAT.** 3441.

See Machines—Gramme type.

1881. **LAKE.** 3456.

See Machines—Gramme type.

1881. **C. LAVER.** 3599.

Improvements in Electric Lamps.

In this lamp the bottom carbon is fixed, the upper carbon being attached

to a rod which is gripped by the bent part of two springs attached to two armatures, one on each side of the rod. The armatures are attracted by polar extensions of an electro-magnet in main circuit. An electro-magnetic short-circuiting arrangement is also shown.

1881. W. R. LAKE. **3668.**

(From T. A. CONNOLLY.)

Improvements in Electric Lighting Apparatus.

Describes a lamp with vertical carbons. Both carbons are moveable; the lower carbon is fed towards the upper one by means of a double clip arrangement. Each carbon passes through two double clips, one fixed and the other moveable, being attached to the armature of an electro-magnet. When the armature is attracted it raises the carbon, and when it descends the upper fixed holder prevents the carbon from also descending.

1881. S. PITT. **3679.**

(From S. J. BURRELL.)

Improvements in Electric Light Regulators.

In this lamp the bottom carbon is fixed, the upper carbon being attached to a rod which passes through the centre of two coils of wire; one of the coils is wound with thick, the other with fine wire. At the bottom part of the inside of the bottom coil, and embracing the top carbon, is a pole-piece, one-half of which is loose and pivoted in one part. When the current passes through the coil the two pole-pieces assume the same polarity and repel each other, and in consequence grip the carbon rod.

1881. A. L. FYFE and J. MAIN. **3821.**

Improvements in Electric Lamps or Regulators.

Describes a form of arc lamp with bottom carbon fixed. The top carbon is held by a brass rod with a rack cut on one side, which gears into a train of wheels. The regulation is effected by an arrangement whereby the whole train of clockwork is raised by means of a solenoid or electro-magnets, and which separates the carbon. The movement is allowed to run without the whole descending, by means of an armature or core moving in a solenoid retaining a spring which presses on the fly- or brake-wheel of the movement.

1881. P. JENSON. **3976.**

(From A. J. B. CANCE.)

Improvements in Electro Arc Lamps.

Describes a form of arc lamp with both carbons moveable. The regulation is effected by means of a long spiral screw. On the screw is a block which falls when the screw is allowed to turn. Two rods holding the top carbon are attached to this block. To the upper end of these rods are attached cords which pass over pulleys and raise the bottom carbon; on the descent of the rods the separation of the carbons is effected by mans of an iron core working on a solenoid raising the top carbon.

1881. **B. HUNT.** 4011.

(From A. E. BROWN.)

Improvements in Electric Lamps.

Describes several forms of lamps where the regulation is effected by means of a piston working in a cylinder containing a fluid, a valve in the piston being opened or closed by a lever connected to an iron core working in a solenoid, thus allowing the fluid to pass from one part of the cylinder to another.

1881. **E. H. HARLING and E. HARTMANN.** 4373.

Improvements in Electric Lamps, etc.

In this lamp both carbons are moveable. The regulation is effected by means of several wheels driven by the weight of the top carbon rod; to one of the wheels is attached an iron disc which is made to revolve in front of the poles of an electro-magnet, and is held by same when the current passes through the electro-magnet coils.

1881. **J. BROCKIE.** 4504.

Improvements in Electric Arc Lamps.

Describes a lamp with two sets of vertical carbons, the bottom carbons being fixed. The upper carbons are attached to rods which are free to fall by their own weight, and are held by cam levers which are moved by the armature of an electro-magnet.

1881. **F. M. NEWTON.** 4559.

Improvements in Apparatus for Generating and Utilising Electricity.

Describes a lamp with vertical carbons, both carbons being moveable. The bottom carbon is raised by a weight pressing on the upper carbon by means of cores passing over pulleys; the upper carbon is regulated by means of a small circular roller which presses against the carbon rod.

1881. **A. M. CLARK.** 4617.

(From H. H. SHERIDAN.)

Improvements in Electric Lamps.

Describes a form of lamp with vertical carbons, both carbons being moveable. The bottom carbon is raised by a cord which passes under a pulley at the bottom of the holder; the top carbon is allowed to descend by means of a cord. Both cords pass over a cone pulley having a ratchet-wheel attached. An oscillating arm which moves the ratchet-wheel is in connection with an iron core working in two coils of wire, one of high resistance and the of other low resistance. By the movement of the arm the carbons are allowed to come together; a pawl which fits in the teeth of the ratchet-wheel prevents the backward movement of the same.

1881. H. A. BONNEVILLE. 4775.

(From L. DAFT.)

Improvements in Electric Lamps.

In this lamp both carbons are moveable. The bottom carbon is arranged to move upwards by being immersed in mercury, the movement of the carbon being arrested by a claw which is situated at the end of the rod where it is tapered close to the arc; the upper carbon is contained in a tube, and rests by its own weight at its taper end on a claw. The arc is formed by means of a hollow iron core which embraces the top carbon tube, and is drawn upwards within a solenoid.

1881. E. R. PRENTICE. 4777.

Improvements in Electric Lamps.—(Provisional.)

In this lamp the bottom carbon is fixed, the upper carbon being attached to a piston-rod which moves in a cylinder containing glycerine. A valve is actuated by an iron core moving in a solenoid, and which stops or allows a free passage for the glycerine to pass from one part of the cylinder to another.

1881. W. LLOYD WISE. 4820.

(From E. BURGIN.)

Improvements in Electric Lamps or Regulators.

Describes a lamp with two sets of vertical carbons. The lower carbons are fixed; the upper carbons are attached to two rods, each of which have a rack cut on one side gearing into pinions to which is attached a brake-wheel. An armature of iron, placed vertically and opposite to and at a short distance below the poles of an electro-magnet, is drawn upwards on the passing of a current through the lamp, and carries with it the carbons and rods, and also the brake-wheel, which presses against a shoe fixed to the frame of the lamp, and thereby holds or secures the carbon rods at the moment the arc is formed.

1881. G. G. ANDRE. 4948.

Improvements in and connected with Electric Lamps.

In this the bottom carbon is fed upwards by a step-by-step action, regulated by a constantly intermittent current conveyed by a separate wire; the upper carbon is fixed, except when the arc is to be formed, when it is raised by a lever attached to the armature of an electro-magnet.

1881. E. G. BREWER. 5185.

(From A. G. WATERHOUSE.)

Improvements in Electric Lamps.

The bottom carbon of this lamp is fixed; the upper carbon being attached to a rod which is allowed to fall by its own weight, except when it is held by a clutch which is actuated by the moveable polar extensions of an electro-magnet.

1881. **W. F. KING and A. B. BROWN.** 5272.

Improvements in and connected with Electric Lamps.

Describes a form of arc lamp where the bottom carbon is fixed, the top carbon being regulated by means of air, the air being allowed to escape from a cylinder, and allowing the piston which is connected to the top carbon-holder to fall. A valve is opened and closed by means of an iron core working in a solenoid in shunt circuit.

1881. **H. E. NEWTON.** 5295.
(From A. J. GRAVIER.)

Improved Mechanism for Regulating the Feed of Electrodes in Electric Lamps.

Describes an arc lamp with vertical carbons, the bottom carbon being fixed. The regulation of top carbon is effected by means of clockwork, which is released by an electro-magnet in shunt circuit.

1881. **C. F. VARLEY and F. H. VARLEY.** 5396.

Improvements in Electric Lamps.

In this lamp the bottom carbon is fixed, the upper carbon being moved downwards by a spring pressing against a piston to which is attached the upper carbon-holder. Four guide rollers, two on each side of the carbon rod and pressing against same, are used to hold the carbon when the lamp is burning, and are prevented from moving by means of arms acting as brakes on the two bottom rollers. The arc is formed by means of an electro-magnet raising the top frame and tube.

1881. **W. R. LAKE.** 5490.
(From J. A. MONDOS.)

Improvements in Electric Lamps or Lighting Apparatus.

Describes a form of arc lamp where the bottom carbon is fixed, the upper carbon being secured to a rod which is regulated by means of brake-lever actuated by an electro-magnet.

1881. **KENNEDY.** 5524.
See Lamps—Incandescent in Vacuum.

1881. **L. S. POWELL.** 5660.
(From J. M. A. GERARD LESCUYER.)

Improvements in Electric Lamps.

Describes a form of lamp with both carbons moveable. The regulation of the carbons is effected by allowing air to enter a cylinder in which a piston moves in connection with upper and lower carbon-holders.

1881. **S. A. VARLEY.** 5665.

Improvements in Apparatus for Producing and Regulating Electric Light, partly applicable to other uses.

Describes two forms of arc lamps with vertical carbons. In the first the

bottom carbon is fixed, the upper carbon being attached to a holder having a spiral wire wound on it, the opposite sides of which are bare, on which press contact-rollers. This coil and holder pass through the hollow core of an electro-magnet, and are acted on by the same in the regulation of the burning of the carbons.

In the second lamp described the heated air drives a fan in connection with bevel-wheels for regulating burning of the carbons.

1882. G. HAWKES. 157.

Improvements in Apparatus for Electric Lighting.

In this lamp the bottom carbon is raised by means of weights attached to cords passing over pulleys, the movement of the carbon-holder being regulated by a gripping-piece attached to the armature of an electro-magnet. The top carbon is attached to a holder which is affixed to the armature of an electro-magnet, and is used to form the arc.

1882. B. ABDANK. 339.

Improvements in Regulating Electric Lamps and in Apparatus specially devised for the purpose.

Describes a form of automatic regulator to be used in conjunction with an arc lamp. This regulator is in electrical connection with an electro-magnet on the lamp, actuating an armature to which is attached a pawl giving movement to a ratchet-wheel, and thereby giving movement to the upper carbon of a lamp. There are two coils on the regulator, one with thick wire and the other with thin wire; a moveable iron core is placed in the middle of the coils of wire, so that when it moves towards the fine wire coil, a contact-lever is allowed to move, and so places in circuit the regulating coil of the lamp. Resistance coils are also placed in the derived circuit by means of a sliding contact arrangement.

1882. R. E. B. CROMPTON. 346.

Improvements in Electric Lamps and in Apparatus used in conjunction with Electric Lighting.

In this lamp both carbons are moveable, the bottom one being attached to a holder which is made to rise by the weight of the upper carbon-holder, by means of cords passing over pulleys. The downward movment of the upper carbon is regulated by a train of wheels, the end wheel of the train consisting of a plain disc or wheel, so that a brake-strap, which is attached to the armature of an electro-magnet when it is applied to the wheel, prevents the wheels from moving, and also the carbon rod from descending; the carbons are separated to form the arc, by means of another electro-magnet, the armature of which, lifts the whole train of wheels, and consequently the carbon and rod with it.

1882. **C. T. BRIGHT.** 377.

Improvements in Electric Lamps.

In this lamp the bottom carbon is fixed, the top carbon being attached to a rod which is held by means of two gripping-arms, which are actuated by an armature attached to an electro-magnet; the arc is formed by means of another electro-magnet placed on the top of the lamp, and which, by means of the armature, raises the top carbon rod, and forms the arc.

1882. **W. P. THOMSON.** 392.

(From Union Electric Manufacturing Company.)

Improvements in Obtaining Light by Electricity, etc.

Describes a lamp with vertical carbons, the bottom carbon being fixed. The upper one is attached to a rod which has a rack cut on one side, this rack gearing into a pinion, attached to which is a brake-drum; inside this drum is a bent armature which operates on a brake or clutch, and holds the top carbon. The arc is formed by the drum being moved backwards by means of the armature, taking up a position opposite the two extended poles of an electro-magnet coil which partly embraces the brake-drum.

1882. **B. J. B. MILLS.** 578.

(From W. M. Thomas.)

Improvements in Electric Lamps.

Describes a lamp with vertical electrodes, the bottom electrode being fixed, the upper one being attached to a rod, to the other end of which is attached the iron core of a solenoid. The solenoid consists of a long coil of wire, on the opposite side of which the covering is removed, and rollers make contact with same on the descent of the rod.

Describes using as bottom electrode a copper rod tipped with iridium.

1882. **A. J. JARMAN.** 563.

Improvements in Arc Electric Lamps.

In this lamp the bottom carbon is fixed. The upper carbon is attached to a rod, which is secured by means of two cross arms which grip the rod when the lamp is burning; an iron core working in a solenoid pulls the two arms together.

1882. **A. J. JARMAN.** 565.

Improvements in Arc Electric Lamps.

Describes a form of lamp with bottom carbon fixed, the upper carbon being attached to a rod which is gripped by two arms placed crosswise, and attached to which is the armature of an electro-magnet. By the attraction of the electro-magnet the two arms are caused to grip the rod and raise the carbon to form the arc. On the armature descending the rod falls through, thereby regulating the feed of the carbons.

1882. **A. A. COMMON.** 626.

Improvements in Electric Lamps.

In this lamp the lower carbon is fixed, the upper carbon being attached to the end of a steel tube containing mercury, and having within the tube a piston and rod. The tube is held by means of a tube and toe-piece attached to a lever in connection with an iron core working in a solenoid. The arc is formed by means of the toe-piece and tube raising the upper carbon.

1882. **J. RAPIEFF.** 831.

Improvements in Electric Lamps, etc.

Describes various methods of regulating the feeding of carbons by means of cords and weights, and also by means of fluids under pressure contained in cylinders and acting on pistons, to the rods of which are attached the carbon-holders.

1882. **W. R. LAKE.** 834.

(From B. LANDE.)

Improvements in Electric Lamps or Lighting Apparatus.

Decribes a form of lamp with vertical carbons, the bottom carbon being fixed; the upper carbon is attached to a metal rod which passes between two grooved pulleys. An electro-magnet is provided with moveable cores. Attached to the cores are partly circular brake-arms, which press against the pulleys when the current is passing through the lamp, and prevent the carbon from falling. The brake-arms also serve to lift the pulleys, carbon, and holder-rod in forming the arc when the current is put on.

1882. **J. BROCKIE.** 898.

Improvements in Electric Arc Lamp.

In this lamp both carbons are moveable. The bottom carbon is attached to the end of a rod, on one side of which is a rack gearing into a pinion, to which is fixed a toothed wheel made to rotate by means of a ratchet-wheel and pawl, the pawl being attached to the armature of an electro-magnet. The upper carbon is regulated by means of a clutch actuated by an armature opposite an electro-magnet coil.

1882. **A. GRAHAM.** 1171.

Improvements in Mechanism for Regulating the Burning of Carbon or other Electrodes.

In this lamp both carbons can be arranged to move, or one only. The upper carbon is attached to a rod on one side of which, is a cord or chain which passes round a pulley, to which is attached a drum, on one end of which are teeth which give an oscillatory movement to an arm carrying a series of pins or a comb. A knife-edge fixed to the armature of an electro-magnet is arranged to engage or disengage in the comb or series of pins. When the current passes, the knife-edge engages in the comb and holds the

upper carbon, while the bottom carbon strikes the arc. When the arc becomes too long the knife-edge disengages from the comb and allows the carbons to approach, and then the comb is again held.

Another form of lamp is described with vertical carbons, in which the bottom carbon is fixed. The upper carbon is attached to a rod on one side of which, is a rod having teeth cut on one side, into which an oscillating pawl engages. The object of the pawl oscillating is to allow the arc to be formed. Over the top carbon rod is fitted a brass sleeve or tube carrying an armature opposite the poles of an electro-magnet. When the current passes through the lamp the sleeve raises the top carbon rod, and when the arc becomes too long, and the magnet becomes weakened, the rod passes by the pawl and then the armature is attracted, and the brass sleeve slides over the rod, and is then ready for another downward movement.

1882. LEVEY. 1249.

See Machines—Gramme type.

1882. W. R. LAKE. 2563.

(From J. J. Wood.)

Improvements in Electric Lamps or Lighting Apparatus.

Describes a form of lamp with bottom carbon fixed. The upper carbon is attached to a rod, on one side of which is a rack which gears into a pinion connected with a train of wheels, the movement of which is regulated by means of a lever attached to an iron core working between thick and thin wire coils.

V. HORIZONTAL CARBONS, thus, —— ——

1878. W. B. BRAIN. 5139.

Improvements in Apparatus for the Production and Application of Electricity for Lighting, etc.

Describes a lamp with the two carbon electrodes placed horizontally, a third carbon being placed vertically over the points of them. The regulation is effected by means of cords attached to a bracket supporting a double electro-magnet which slides between two uprights. The electro-magnet performs two functions, one being to bring the two horizontal carbons together by its weight, and the other to grip the top carbon rod in its descent.

1878. BRAIN. 5139.

See Machines—Gramme type.

1879. G. P. HARDING. 4590.

Improvements in Apparatus and Mechanism for Electric Lighting.

Describes lamp where the carbon pencils or rods are placed horizontally and parallel to each other, with suitable mechanism for actuating the same.

1880. **A. M. CLARK.** 75.

(From R. Rognier.)

Describes a form of arc lamp with a right- and left-handed screw arrangement for bringing the carbons together as they are consumed.

1880. **A. M. CLARK.** 842.

See Carbons combined with Non-Conductors.

1880. **C. W. SIEMENS.** 4614.

Improvements in Electric Lamps.

Describes a form of lamp where the carbons are placed horizontally, and regulated by means of feed-rollers and ratchet-rods.

1881. **W. R. LAKE.** 48.

(From E. Etève.)

Improvements in Apparatus for Generating and Utilising Electricity for Lighting and other purposes.

Describes a form of lamp with carbons placed horizontally and resting on rollers, the carbons being moved towards each other by means of ratchet-wheels and pawls in connection with gearing.

1881. **B. J. B. MILLS.** 2788.

(From F. Million.)

Improvements in Means or Apparatus employed for Obtaining Light by Electricity.

Describes a form of lamp with carbons placed horizontally, and which are brought towards each other by means of cords. One end of each cord passes over a pulley and is then attached to a weight. The other ends of the cords are wound on a drum in connection with several wheels and a regulating fly. The regulation is effected by the movement of an armature of an electro-magnet, to which is attached a click or pawl which causes the wheels to rotate.

1881. **LAKE.** 5477.

See Carbons combined with Non-Conductors.

1882. **W. J. MACKENZIE.** 95.

Improvements in or connected with Electric Lamps.

Describes a form of lamp with carbons placed horizontally, the carbons being held in tubes and pressed forward by means of spiral springs. The taper ends of each of the carbons are made to press against the ends of three screws. One carbon-holder is suspended to pivoted brackets, so that it can be separated when the current is passed through the lamp.

1882. **A. M. CLARK.** 740.

(From Solignac & Co.)

Improvements in Electric Lamps and in Generators, etc.

Describes a lamp with the carbons placed at a slight angle from being horizontal, the ends of the carbons abutting against a fixed stop.

1882. **GRAHAM.** 1171.

See Lamps, Arc—Vertical Carbons.

VI. SEMICIRCULAR CARBONS.

1878. **C. F. HEINRICHS.** 4595.

Improved Means, etc., for Generating Electricity, and in an Improved Lamp.

Describes a lamp with semicircular carbons arranged to approach each other by the weight of the holder, and regulated by a train of wheels which is actuated by means of an electro-magnet.

1879. **C. DUBOS.** 427.

Improvements in Electric Lamps.

1879. **W. R. LAKE.** 2111.

(From J. Puvilland and T. Raphael.)

Improvements in Electric Lighting Apparatus.

1880. **W. L. WISE.** 2417.

(From J. A. Mandon.)

Improvements in Electric Light Apparatus.

Uses rods of carbon, each formed of an arc of a circle and connected and attached to balance levers, the opposite ends of the levers to which the carbons are attached, being connected to floats with curved arms, which are enclosed within a tube containing mercury or other liquid. The arc is formed at the upper extremities of the carbons.

VII. CARBONS COMBINED WITH NON-CONDUCTORS.

1878. **C. H. SIEMENS.** 3134.

Improvements in Apparatus for the Dynamical Production, etc., of Electricity, and for its Regulation when applied for Illumination.

Describes various lamps. In one the carbons are placed at an angle, the ends meeting upwards, and are separated by a badly-conducting refractory material.

Also a lamp is described with vertical carbons, the bottom carbon being raised by means of a float immersed in a vessel containing mercury. The upward movement of the lower carbon is arranged to feed the upper carbon.

1878. STUART-WORTLEY. 3656.

See Electrodes for Arc Lamps.

1878. HICKLEY. 4132.

See Electrodes for Incandescent Lamps.

1878. J. N. AROSON and H. B. FARNIE. 4163.

Improvements in Electric Lighting, etc.

Describes the manufacture of electrodes of ruthenium, osmium, and rhodium, either singly or mixed together, or mixed with plaster of Paris, asbestos, etc.

1878. J. H. JOHNSON. 4690.

(From A. De Meritens.)

Improvements relating to Electric Regulators, Lamps, or Candles.—(Provisional.)

Places a Jablochkoff or other suitable candle under glass in the form of a test tube, and states that the carbons will last three or four times as long under these conditions.

1878. J. L. PULVERMACHER. 4774.

Improvements in and connected with Producing Light by Electricity.

Describes electrodes for arc lamps of a mixture of finely powdered charcoal and tar or pitch. The mixture is enclosed in a cylinder of non-conducting material, and outside this cylinder is wound spirally an electrode of same material as the inner core; the arc is formed from the inner electrode to the outer spiral electrode.

Also describes method of rendering incandescent a fine platinum wire.

1878. A. V. NEWTON. 4960.

(From Weston Dynamo Machine Co.)

Improvements in Apparatus for Generating Electric Currents and for Producing Electric Light.

Describes various methods of connecting the ends of the coils to the commutator.

Also describes the use, with vertical parallel carbons, of a material capable of being volatilised by the heat of the arc, and forming a conducting vapour which allows the arc to retain itself in a prescribed path.

1878. S. COHNÉ. 5011.

A New or Improved Electrode or Electric Candle for Lighting by Electricity, etc. (Provisional.)

Describes electrodes of a mixture of ultramarine, carbon, and molasses,

and using with same, kaolin, plaster of Paris, or silicate of soda or silicate of potash, etc. Also describes placing a copper wire through centre of candle.

1878. **H. WILDE.** 5197.

Improvements in Apparatus for Producing and Regulating Electric Light.

Describes a lamp with parallel vertical carbons which are raised by means of cords with weights attached to the other ends; the upper ends of carbons rest against a refractory substance.

1879. **K. W. HEDGES.** 81.

Improvements in Electric Lamps.

Describes a form of lamp where the two carbon electrodes descend in tubes or guides, and rest on a refractory material, the luminous arc being formed on the same material.

1879. **W. M. BROWN.** 144.

(From W. F. C. McCarty and R. Sellière.)

Improvements in the Production of Electric Light, as well as in the Materials and Mechanism employed for that purpose.

Exposes certain chemicals to the action of heat produced by the heat of the arc. Also describes a lamp for use with same, where the carbons are contained in tubes and placed at an angle; the carbons are raised by means of springs contained within the tubes, and are made to press against a piece of chemically pure calcium placed above the carbons. Between the ends of the carbon rods is placed a pellet composed of an alloy of platinum and iridium, supported on a piece of asbestos.

1879. **RAPIEFF.** 211.

See Machines—Miscellaneous.

1879. **J. D. F. ANDREWS.** 416.

Improvements in Electric Lamps.—(Provisional.)

Uses two discs of carbon placed side by side, the arc being formed at the periphery of the discs. Plaster of Paris or other insulating substance can be placed between the carbon discs.

1879. **G. P. HARDING.** 783.

Improvements in Apparatus or Appliances for Obtaining Electric Light.

Describes heating lime or other refracting earth by electric arc, and covering carbons with same.

1879. **ANDRÉ.** 830.

See Lamps—Semi-Incandescent.

1879. **K. W. HEDGES.** 925.

Improvements in Electric Lamps.

Describes a lamp with the carbons placed at an angle, the ends resting on a refractory material.

1879. ST. G. LANE-FOX. **1122.**

Improvement in the Means or Apparatus for Obtaining Light by Electricity, and in the Manufacture of Materials to be employed therein.—(Provisional.)

Describes method of rendering incandescent a mixture of plumbago and a non-conducting material, such as magnesia, zirconia, lime, steatite, or earthy matter.

Also describes coating the above with a film of carbon.

1879. J. C. IMRAY. **1175.**

(From Société Generale d'Electricité.)

Improvements in Electric Candles.

Describes placing carbons side by side, and separated by an insulating material.

1880. A. M. CLARK. **842.**

(From L. J. Bouteilloux and W. Laing.)

Improvements in Means or Apparatus for Producing the Electric Light.

Describes the use of a solid carbon rod as one electrode, and of a tube of carbon filled with an insulating material as the other electrode, the top carbon resting against the insulating material, and the light being given off from the tube to the carbon rod. The electrodes are also shown in a horizontal position, being brought together by means of weights.

1880. H. J. HADDAN. **1704.**

(From A. Bureau.)

Improvements in Electric Lamps.

Describes a lamp where carbons approach each other in form of a V, the lower ends resting in and guided by a block of refractory material.

1881. J. J. JACHS. **894.**

Improvements in Electric Lamps.

Describes a lamp with the carbon rods placed at an angle and resting on the ends of holes made in a plate of asbestos; the arc is started by means of a piece of graphite being placed between the ends of the carbon rods, which burns away and so forms the arc.

1881. J. L. A. DUPONT-AUBERVILLE. **1536.**

(From V. Delarge.)

Improvements in Electric Lamps.

Describes a form of lamp in which electrodes are parallel and horizontal, and are pressed forward against non-conducting refractory abutments, so arranged that the ends of the electrodes overlap each other.

1881. J. B. ROGERS. 1922.

Improved Construction or Arrangement of Electric Lamp.

Describes a form of lamp with the carbons placed at an angle, the apex of the angle of the carbons being downwards. Vertical strips of asbestos or talc are placed between the ends of the carbon rods.

1881. A. M. CLARK. 3214.

(From L. J. Bouteilloux and W. Laing.)

Improvements in Electric Lamps.

Describes a lamp with vertical carbons, the lower carbon being fixed. The upper carbon or electrode descends by its own weight and rests on the bottom carbon; it consists of a carbon cylinder filled with an insulating material. Another lamp is shown where the carbons are placed at an angle and are made to rise by means of a weight; the ends of the carbon rods rest against an insulated core of an electrode placed above the ends of the carbons.

1881. C. W. HARRISON. 3559.

Improvements in Electric Lighting and in the Means or Apparatus employed therein.

Partially surrounds a Wilde electric candle with a refractory block of uncrystallised oolite, known as roestone.

Also describes a block of same placed above the arc formed on top of the carbons.

1881. G. PFANNKUCHE. 3650

Improvements in or connected with Electric Lamps.—(Provisional.)

Describes method of coating the filament with china clay, and fused in solid block of glass.

1881. A. TUBINI. 3822.

An Improved Electric Lamp or Regulator.

In this lamp the carbons are at an angle, one of the carbons being covered with kaolin. The arc is formed by means of a solenoid which causes one of the holders to move.

1881. ROGERS. 4855.

See Semi-Incandescent.

1881. W. R. LAKE. 5477.

(From C. De la Roche.)

Improvements in Electric Lamps or Lighting Apparatus.

Describes placing the carbons horizontally with the ends resting against any kind of refractory material, and contained in a chamber of the same.

VIII. AUTOMATIC SWITCHES & SHUNTS FOR JABLOCHKOFF CANDLES AND OTHER ARC LIGHTS.

1879. F. MORI, C. E. HALLIWELL, W. MILNER, and W. GRIFFEN. **740.**

Improvements in Electric Lamps, and in the Method of and Apparatus for Regulating or Controlling the same.

Describes an apparatus consisting of a plate of metal which carries a number of Wilde candles, and arranged so that when one candle is almost consumed another candle is put in circuit, and so on until all are consumed.

1879. A. M. CLARK. **1971.**
(From N. E. Reynier.)

Improvements in Lighting by Electricity.—(Provisional.)

Describes an automatic switch which is brought into operation on the extinction of a lamp, and which by means of the armature of an electro-magnet is then made to close a circuit with another lamp.

1879. W. B. GODFREY. **4718.**

Improvements in the Apparatus for Holding the Electrodes for Use in Electric Lighting. (Provisional.)

Describes an apparatus with a number of carbon-holders, with carbons placed either parallel like the steps of a ladder, or arranged like the spokes of a wheel. By an arrangement of the holders, when one pair of carbons has been burnt down to a given point another pair succeeds to the position occupied by the first.

1879. T. E. GATEHOUSE. **4796.**

Improvements in Electric Lighting Apparatus.

Describes an apparatus where a number of carbon candles are fixed radially round a centre, and made so that each candle shall be in the same plane while burning.

1881. J. G. TONGUE. **715.**
(From A. Lacomme.)

Improvements in and connected with Electric Lamps, etc.

Describes an arrangement for putting in circuit another pair of carbons or candles after the first are consumed, or more than two sets of carbons can be used.

1881. J. A. BERLY. **1236.**

Improvements in Electric Lamps, Candles, Candle-holders, and Apparatus connected therewith.

Describes various methods for automatically switching electric candles.

1881. **W. R. LAKE.** 1968.

(From N. Bouliguine.)

Improvements in Electric Lighting Apparatus.

Describes a number of sets of carbons, having each set arranged with carbons slanting towards each other at top; and also describes a method for automatically putting one set in circuit after another, by means of an electro-magnetic arrangement.

1881. **P. L. M. GADOT.** 2344.

Improvements in Electric Lighting Apparatus.

Describes an automatic switch arrangement which causes another candle to be placed in circuit when one is burnt away, etc. This is effected by means of a spring expanding and making contact with another set of carbons.

1881. **JENSEN.—(Edison.)** 2492.

See Lamps—Incandescent in Vacuum.

1881. **W. R. LAKE.** 2520.

(From J. J. Wood.)

Improvements in Electric Lamps or Lighting Apparatus.

Describes an arrangement to be used in lamps where more than one set of carbons are used, consisting of a lever clutch pressing and holding the top carbon-holder rod of the second set of carbons, and which prevents the second set from being regulated until the end of the upper carbon rod releases the lever.

1881. **W. R. LAKE.** 3893.

(From W. S. Hill.)

Improvements in Electric Lighting Apparatus.

Describes a form of switch to be attached to an arc lamp, so that when the carbons have burned as low as desired, the switch acts mechanically to divert the current from its course through the carbons to a more direct passage, whereby the regulating mechanism is rendered inoperative and the light extinguished without affecting the other lamps in the circuit.

1881. **JAMIESON.** 4439.

See Lamps—Incandescent in Vacuum.

1881. **HARRISON.** 4478.

See Electrodes for Incandescent Lamps.

1881. **R. R. GIBBS.** 4533.

Improvements in Electric Lamps.

Describes an automatic switch which is used to close the circuit of another candle as soon as one is consumed, and is effected by means of a spring which presses against the bottom of one carbon, so that when the candle has been consumed the spring comes into contact with another candle.

1881. **W. E. HUBBLE.** **4792.**

(From J. M. A. GERARD-LESCUYER.)

Improvements in Switches and Apparatus employed in connection with Electric Lamps, etc.

Describes an automatic shunt apparatus, consisting of two metal rods suspended by a platinum spiral which becomes heated by the current and expands, thereby allowing the metal rods to descend into two cups of mercury, and shunt the current from the lamp.

1882. **A. MACKIE.** **14.**

Improvements in Apparatus used for Electric Lighting.

Describes electro-magnet with a metal extension forming a lever and fixed to the armature, the use of which is to make contact with metal studs in connection with a number of lamps. If the current is too strong for first lamp on No. 1 stud, the armature is further attracted until the lever makes contact with No. 2 stud and places the second lamp in circuit; if the current is still too strong, the lever is still further attracted and moves the lever on No. 3 stud and places a third lamp in circuit, and so on.

1882. **J. M. ARONSON.** **359.**

Improvements in and connected with Electric Lamps.

Describes a form of automatic shunt which is used with incandescent lamps which have two filaments, where the second filament is placed in circuit on the failure of the first.

Also describes an arrangement where the lamp can be moved by hand to place a second filament in circuit on the failure of the first.

IX. MISCELLANEOUS.

1878. **W. S. WILSON.** **3912.**

Improvements in the Manufacture of Electric Light and Apparatus therefor.
(Provisional.)

Describes the passing of a metallic vapour or hydro-carbon across arc.

1878. **G. FORBES.** **4116.**

Improvements in Electric Lighting.—(Provisional.)

Describes the use of carbon rods to which a mechanical movement is applied, causing a sufficient rapid make and break of contact to form the arc.

1878. **C. W. SIEMENS.** **4208.**

Improved Means and Apparatus for Electric Illumination.

Describes electrodes which are kept cool by water or air passing through pipes or tubes placed near the arc.

1878. **G. ZANNI.** 4573.

Improvements in the Production of Light by Electricity.

Describes a lamp with long cylinders or rods of carbon placed parallel to each other and made to rotate, the arc being formed at the periphery of the rods.

1878. **G. WHYTE.** 5152.

Improvements in Electric Lamps and in the Electrodes or Appliances connected therewith.

Describes a lamp with two revolving discs of carbon, between the peripheries of which the arc is formed.

1878. **J. B. FREEMAN.** 5307.

Improvements in Carbons employed in the Production of the Electric Light (Provisional.)

Carbons are made in the form of a helix of considerable diameter, and may be both right- or left-handed, or one right- and the other left-handed.

1879. **G. REMINGTON.** 192.

An Improved Method of, and Apparatus for, Preventing Rapid Consumption or Destruction of the Electrodes used in Electric Lighting.—(Provisional.)

Describes electric light developed in an atmosphere where there is no oxygen, or only a very small proportion.

Also describes the use of water or other liquid or steam, to prevent rapid destruction of carbons.

Also describes placing the carbons in globes and passing hydrogen or mixture of gases known as coal gas through them.

1879. **R. E. B. CROMPTON and P. W. WILLANS.** 245.

Improvements in Apparatus employed in Electric Lighting.—(Provisional.)

Describes use of rotatory discs or cylinders of carbon.

1879. **J. IMRAY.** 382.

Improvements in Electric Lamps.—(Provisional.)

Describes the use of carbon cylinders or tubes, the arc being formed at the lip or edge.

1879. **ANDREWS.** 416.

See Carbons combined with Non-Conductors.

1879. **M. A. WIER.** 684.

Improved Means and Apparatus for Producing Light by Electricity.

Describes method of using a stream of particles of carbon made to pass across the arc.

1879. **ANDRÉ.** 830.

See Lamps—Semi-Incandescent.

1879. **C. D. ABEL.** 863.
(From J. C. JAMIN.)

Improvements in Electric Lamps.

The arc is placed under the influence of a magnet or solenoid, causing it to rotate. Arrangements are shown for adapting the theory to lamps of various patterns.

1879. **C. W. SIEMENS.** 2110.

Improved Means and Apparatus for Producing Light by Electricity.

Describes a form of lamp where the negative electrode consists of an iron wire kept cool by a circulation of water. The positive carbon is made to slide in a tube; the lower end of the carbon resting against a pin or other refractory metal.

1879. **G. GROUT and R. SENNET.** 2267.

An Improvement in Illuminating by Electricity.

To increase the illuminating power of the electric arc by passing gases or vapours rich in carbon or other substances which, becoming incandescent, increase the light.

1879. **WHYTE.** 2744.
See Lamps—Semi-Incandescent.

1879. **HEINRICHS.** 4589.
See Machines—Gramme type.

1880. **A. M. CLARK.** 636.
(From C. L. PILLEUX.)

Improvements in Producing the Electric Light.

Describes an arc lamp with two carbon electrodes resting on two other carbons, so that contact is made in two places at end of each carbon.

1880. **R. T. D. BROUGHAM.** 832.

An Improvement or Improvements in or connected with Electric Lamps.

Describes an arrangement where air is excluded from the lamp while burning, and which is effected by means of one tube contained within the other, between which liquid is placed.

1880. **HEINRICHS.** 4608.
See Machines—Gramme type.

1881. **J. A. BERLY.** 1027.

Improvements in Electric Lamps, Candle-holders, etc.—(Provisional.)

Describes improvements in holders, etc., for Jablochkoff candles.

1881. **T. TUBINI.** 3635.

Improvements in the Production of the Electric Light.—(Provisional.)

A stream of carbonaceous matter, such as ordinary gas or hydro-carbon oil, is passed across the arc from one electrode to the other.

INCANDESCENT.

X. INCANDESCENT IN VACUUM.

1878. **ST. GEORGE LANE-FOX.** 3988.

Improvements in Obtaining Light by Electricity, etc.

Describes rendering incandescent, leaves of platinum or platinum-iridium foil, also fine platinum wire.

1878. **ST. GEORGE LANE-FOX.** 4043.

Improvements in the Application of Electricity to Lighting, etc.

Describes covering the surfaces of the plates of metal foil mentioned in Patent No. 3988, of 1878, with a non-conducting material.

1878. **ST. GEORGE LANE-FOX.** 4626.

Improvements in the Means or Apparatus for Obtaining Light by Electricity, etc.

Describes making the electrode of platinised, iridised, or carbonised asbestos, or other suitable material, supported by terminals, and placed in a vessel with the air exhausted, and containing a gas if desirable.

Also describes a system of distribution similar to the present system used for distributing gas.

1878. **F. J. CHEESBROUGH.** 4847.

(From A. Mann and W. E. Sawyer.)

Improvements in and relating to Electric Lamps, etc.

Describes a carbon rod placed in a vessel containing hydrogen gas, and rendered incandescent.

Also describes making the filament for incandescent vacuum lamps by heating an infusible substance coated with plumbago in a carbon gas or liquid, and connected with one pole of a battery; the other pole of the battery being connected to a piece of carbon immersed in the liquid. On the passage of the current the liquid is decomposed, and a homogeneous layer of carbon is deposited upon the infusible substance; it is then placed in a vessel and exhausted of air.

1879. **T. A. EDISON.** 2402.

Improvements in Electric Lights, and in Apparatus for Developing Electric Currents and Regulating the Action of the same.

Describes the use of a spiral of platinum wire contained in a sealed glass

bulb with the air exhausted therefrom, for one form of lamp. Also describes wires of chemically pure iron and nickel. Also carbon sticks. Also describes a lamp with a cylinder of infusible oxide contained in a sealed glass bulb exhausted of air; platinum conductors are sealed through the glass and connected to the cylinder.

Also describes a machine with revolving armature coils wound round a wood cylinder fixed to the axle of machine. One-half of each coil is on opposite sides of the wood cylinder; the coils are wound parallel to the axle; the armature rotates between two polar extensions of very powerful field electro-magnets.

1879. T. A. EDISON. 4576.

Improvements in Electric Lamps and in the Method of Manufacturing the same.

Describes a lamp with carbon filaments or threads enclosed in a glass bulb and exhausted of air to about one-millionth of an atmosphere.

1879. T. A. EDISON. 5127.

Improvements in Electric Lamps and in the Method of Manufacturing the same.

Describes a method of manufacturing the filament from carbonised paper The paper is exposed to the action of heat in a mould, to drive off the volatile portions.

Also describes various methods of securing the ends of the filament to the conducting wires.

1880. J. W. SWAN. 18.

Improvements in Electric Lamps.

Describes a lamp consisting of a glass vessel from which the air is exhausted to a high degree of exhaustion while the carbon is in a state of incandescence.

1880. J. W. SWAN. 250.

Improvements in Electric Lamps.

Describes method of fixing the platinum wire in the glass, to prevent glass cracking by heat, and also a means of preventing rupture of carbon by making the strip of carbon in form of a hoop, instead of horse-shoe form.

1880. T. H. BLAMIRES. 455.

Improvements in Lamps for Electric Lighting.

The vacuum is produced by a column of mercury placed in a globe or tube, the tube being sufficiently long so as to balance the weight of the atmosphere like a barometer.

1880. T. A. EDISON. 578.

Improvements in Electric Lamps and in the Method of Manufacturing the same.

Prefers to use an incandescent conductor of high resistance, hermetically sealed in a glass chamber.

Also describes a method for more perfectly sealing the glass globes, so that the vacuum can be kept. Fibres of bleached Manilla hemp are used.

1880. W. R. LAKE. **1649.**

(From H. S. Maxim.)

Improvements in and relating to Electric Lighting Apparatus, and the Manufacture of Carbonised Material to form Conductors for the same, and for other purposes.

Describes a lamp with a moveable core and an arrangement of springs for carrying the carbon feeding and regulating mechanism.

Also describes an incandescent lamp having a highly attenuated atmosphere of hydro-carbon vapour.

Also for making carbon conductors for incandescent lamps, by exposing a carbonaceous substance to a great heat in the presence of hydro-carbon gas or vapour.

1880. W. CLARK. **2037.**

(From P. Drew.)

Improvements in Electric Lamps.

Describes a form of incandescent lamp where glass tubes, which surround the wire, are sealed in a portion least subject to expansion and contraction.

Also uses mercury or dry plaster of Paris, chalk, etc., in the sealing tubes.

1880. ST. GEORGE LANE-FOX. **3494.**

Improvements in Electric Lamps, in the Manufacture of parts thereof, and in Apparatus for Exhausting them, the Apparatus being also applicable to other purposes.

Describes improvements in the incandescent lamps described in Patent No. 3988, 4043, or 4626, of 1878.

Describes the manufacture of carbons from vulcanised fibre.

Also describes an improved method of exhausting by use of mercury.

1880. E. G. BREWER. **3765.**

(From T. A. Edison.)

Improvements in Electric Lamps and in Carbons or Incandescing Conductors therefor, and in Means for and Methods of Manufacturing the same.

Describes improvements on his previous patent.

1880. W. R. LAKE. **4393.**

(From H. S. Maxim.)

Improvements in Electric Lighting Apparatus.

Describes improvements in his previous patent, No. 1649, of 1880.

1880. W. R. LAKE. **4495.**

(From J. V. Nichols.)

Improvements in Electric Lighting Apparatus.

Describes a method of sealing the conducting wires in the glass of an incandescent lamp by means of metallo-vitreous cement.

1880. **J. W. SWAN.** **4933.**

Improvements in Electric Lamps and in the Materials employed in their Construction.

Describes improvements in the manufacture of the lamps of previous patent.

1880. **J. W. SWAN.** **5014.**

Improvements in and connected with Electric Lamps.

In this lamp the filament is formed of cotton thread converted by the action of sulphuric acid, and carbonised by heating with powdered carbon, to prevent oxidation.

Also describes various means for securing the ends of the filament to the conductors.

1880. **D. G. FITZGERALD.** **5272.**

Improvements in and relating to Means and Apparatus for Electric Lighting, etc.

(Provisional.)

In this system the filament is composed of a carbonaceous conductor by carbonising unwrought vegetable fibres.

Also describes a method of treating the fibres with solutions rich in carbon and salts of refractory metals, etc.

1881. **ST. G. LANE-FOX.** **225.**

Improvements in Electric Lamps and Manufacture thereof, etc.

Describes improvements in the manufacture of carbon filaments, and refers to his previous Patents of 1878, Nos. 3988, 4043, and 4626, and of 1880, No. 3494.

Uses vegetable threads wound round a refractory material of pear-shaped section, at the narrow end of which is a steel cutting-edge. When it is heated, the threads break at the cutting-edge; the filaments are then placed in an atmosphere of coal gas, and an electric current passed through them, and raised to a white heat. The carbon ends are thickened by depositing the carbon from the surrounding gas on them; contact may be made at the ends with platinum wires by using Indian ink.

1881. **E. G. BREWER.** **539.**

(From T. A. Edison.)

Improvements in and connected with Electric Lamps.

Describes improvements in the manufacture of incandescent lamps, viz.:— Supporting conductors and filament on a glass pillar. A means of varying intensity of light by inserting resistance. Also describes details of fittings.

1881. **E. G. BREWER.** **768.**

(From T. A. Edison.)

Improvements in connecting the Ends of the Carbon to the Conducting Wire in Electric Lamps.

The ends of the filament are clamped to the wires by mechanical means, and a metal electro deposited on the ends.

1881. **ST. G. LANE-FOX.** 1543.

Improvements in Electric Lamps.

The platinum wires and the bridge are connected by means of cylinders or blocks of carbon or plumbago.

Also describes the use of tubes containing mercury for making connection from inner part of lamp to outer wires.

1881. **J. H. JOHNSON.** 1653.

(From Société de la Force et la Lumière et Société Générale d'Électricité.)

Improvements in Electric Lamps.

Describes an incandescent lamp having a conductor consisting of a series of pieces of carbon or iridium or other suitable conductor placed side by side and between the terminal wires of tbe lamp.

In another form of lamp a number of carbon rods are placed at various angles so that their points meet at one place, and the ends rendered incandescent on the passage of the current.

1881. **P. JENSEN.** 2492.

(From T. A. Edison.)

Improvements in Electric Lamps and the Manufacture thereof, and in Systems thereof.

Describes various details for manufacturing incandescent lamps; and also the use of a filament larger in section at one end than at the other.

An automatic switch for putting in circuit a resistance when the carbon filament of the lamp fails, is also described.

1881. **H. E. NEWTON.** 2572.

(From C. A. Hussey and A. S. Dodd.)

Improvements in Electric Lamps, etc.

Describes a lamp where a number of carbon filaments are arranged side by side. Describes also a means of revolving the glass and bringing into circuit any one of the carbon conductors.

1881. **E. P. WARD.** 2930.

Improvements in Electric Lamps.

Iron or steel conducting wires are enclosed in glass tubes before being sealed to the globe.

1881. **W. R. LAKE.** 3187.

(From J. V. Nichols.)

Improvements in Electric Lamps or Lighting Apparatus.

The filaments are fixed to conductors embedded in a disc of vitreous cement, such as a composition of potash, silica, and oxide of iron and copper. Copper conducting wires can be used with this arrangement.

1881. W. R. LAKE. **3189.**

(From H. S. Maxim.)

Improvements in and relating to Electric Lamps or Lighting Apparatus, and in the Manufacture of Portions of the same.

Describes an incandescent lamp, the carbon filament consisting of fibrous material carbonised, and bent into proper shape, and then electrically heated to give it a permanent set.

1881. T. E. GATEHOUSE. **3240.**

Improvements in Obtaining Electric Light, and in the Apparatus to be employed therein.

Describes an incandescent lamp where the incandescent conductor is of platinum. Also describes a means of regulating the light by using a carbon filament in conjunction with same, inserted either in parallel or alternative circuits. Also describes using, at the joint where the wings pass through the glass, Chatterton's composition, to keep the joint good. Also describes the placing of the globe containing the incandescent conductor inside another globe.

1881. F. WRIGHT. **3435.**

An Improvement in Electric Lamps operated by Incandescence.—(Provisional.)

A collar is placed over the end of carbon filament and fixed over a wedge-shaped platinum conductor.

1881. F. WRIGHT. **3437.**

An Improvement in Electric Lamps operated by Incandescence.—(Provisional.)

Filament is made from bass fibre boiled in sulphuric acid and carbonised; it is then placed in vapour of hydro-carbon, and successively dipped in oil and heated by current until made of proper conductivity.

Describes closing hole of the vacuum globe by means of a screw point.

1881. W. CROOKES. **3799.**

Improvements in the Construction and Manufacture of Electric Lamps.

Describes method of making glass globes.

Also describes method of coating conductors other than platinum with white enamel.

Describes also the use of a compound wire for conductors, consisting of copper or silver with platinum sheathing.

Also describes an apparatus and method for adjusting the resistance of the filaments.

1881. D. G. FITZGERALD. **3890.**

Improvements in Electric Lamps.

Describes using, in the preparation of carbon filaments or conductors for incandescent lamps, a concentrated solution of zinc chloride.

Also describes the making of the filaments thicker at the ends than at the middle.

1881. **S. HALLETT.** 4017.

Improvements in Electric Lamps, in Electrodes therefor, and in fitting up the same.

Describes the providing of a slight or slender electrode, and supporting the same by a core or foundation of lime mounted between two carbon discs platinised by solution of platinum, and covering the filament by a coating of silicon.

1881. **W. MORGAN BROWN.** 4024.

(From E. M. Fox.)

Improvements in Electric Lamps.—(Provisional.)

Describes the use of a plug so that it can be turned whenever necessary, and utilising the plug to support the conducting wires and filament.

1881. **J. W. SWAN.** 4202.

Improvements in and relating to Incandescent Electric Lamps.

The junction of the filaments and conductors are coated by the local electrical heating of same. The junction is placed in an electrotype bath, and a coating of copper is deposited on it; it is afterwards immersed in a hydro-carbon liquid or vapour, and when heated by a current, a deposit of solid carbon is formed which welds the filament and socket together.

1881. **J. H. JOHNSON.** 4311.

(From C. A. Faure.)

Improvements in Electric Lamps.

Describes the fitting of a metal collar on neck of glass globe, and also a metal plate to the holder of the filament, so that the two can be soldered together. The filament, which is made from graphite, is held by two spring clips.

1881. **A. M. CLARK.** 4405.

(From J. De Changy, né De Deyn.)

Improvements in, and in Apparatus for Producing the Electric Light, and in the Manufacture of Carbons therefor.

Describes the use of a taper spiral of platinum wire surrounding a taper carbon pencil, the carbon resting by its own weight in the spiral of wire; also a carbon pencil resting on two discs of platinum.

Describes also the manufacture of carbons for lamps from piassava, sorghum alfa, rattan, rattan pith, or couch grass, by immersing in sulphuric acid, washing and immersing in a bath of glucose sugar and water. Filaments are also made from long fibred wood.

1881. **J. JAMIESON.** **4439.**

Improvements in Incandescent Electric Lamps.

Describes the use of a number of filaments in a globe, so that if one should be broken or injured another can be put in circuit without destroying the vacuum.

1881. **F. WRIGHT.** **4778.**

Improvements in Incandescent Electric Lamps.—(Provisional.)

Describes a lamp with carbon filament enclosed in a globe, with the conducting wires sealed in the glass, which is made flat where they pass through.

1881. **S. PITT.** **4942.**

(From L. Gaulard and J. D. Gibbs.)

An Improved Method of Applying Electric Currents in the Production of Light, and Lamp employed therefor.

Describes the use of an arrangement in combination with a carbon filament enclosed in a glass globe containing a vacuum, whereby, as the invention states, the total quantity of electricity produced by generator is utilised. Two small spheres of platinum are placed in the lamp, one on each side of the carbon filament, and at right angles to plane of same; a small Rhumkorf coil being connected with these in order to utilise the static charge of the conductor by its influence on the fine wire of the induction coil.

1881. **W. R. LAKE.** **5229.**

(From J. S. Williams.)

Improvements in and relating to the Utilisation of Electricity for Lighting, etc. (Provisional.)

Pulverised carbon or other conducting material is placed in a transparent tube or case, and the air exhausted therefrom.

Also describes having a chamber with a supply of the pulverised carbon, etc., so that as it is consumed a fresh supply can be made in the globe.

1881. **W. R. LAKE.** **5233.**

(From J. S. Williams.)

Improvements in and relating to the Utilisation of Electricity for Lighting or other purposes, etc.—(Provisional.)

Describes the use of a conductor having a series of filaments placed transversely, forming several passages for the current.

Also describes an arrangement for placing in circuit one or more filaments at a time. Also describes the use of platino-iridium wires in an exhausted globe. Also describes various other modifications for incandescent lamp.

1881. **R. KENNEDY.** **5524.**

Improvements in Electric Lamps, etc.

The filament is made from a fibre of the aloe tree, and is attached to the

coiled ends of platinum conductors by depositing carbon on same in a carbonaceous atmosphere.

Also describes an arc lamp with vertical carbons, one carbon being moveable. The bottom carbon is raised by means of weights which pass over pulleys to which are attached ratchet-wheels, and are made to move by means of pawls attached to a cross arm fixed to an iron core working in a solenoid; this cross arm also carries the holder for the upper carbon. The arc is formed by the upper carbon being drawn upwards by means of the iron core working in the solenoid.

1882. E. H. T. LIVEING and C. V. BOYS. **69.**

Improvements in the Manufacture of Incandescent Lamps.

Describes the use of insulated conducting wires (to avoid using platinum wires) passed through narrow glass tubes, and filled in with well-boiled pitch or other resinous compound.

XI. INCANDESCENT WITHOUT VACUUM.

1878. H. W. TYLER. **3985.**

Improvements in Apparatus for Electric Lighting.—(Provisional.)

Describes method of rendering incandescent, platinum or other suitable material.

1878. CLARK. **3991.**

See Subdivision of the Current.

1878. J. L. PULVERMACHER. **4180.**

Improvements in Producing Light by Electricity.—(Provisional.)

Rendering incandescent a number of fine platinum wires or thin pieces of platinum foil.

1878. EDISON. **4226.**

See Machines—Miscellaneous.

1878. J. E. STOKES. **4283.**

Improvements in Obtaining Light by Electricity, and in Apparatus for its Application to Illuminating purposes.

Rendering incandescent a fine wire of platinum or iridium.

Also describes the use of a wire which expands with the heat and diverts the current from the fine incandescent wire.

1878. S. F. VAN CHOATE. **4388.**

An Improved Method of, and Apparatus for Producing Electric Light, etc. (Provisional.)

Describes the use of a semimetallic substance composed of a mixture of

asbestos, mica, platinum, or carbon or other material. It is made in the form of a ribbon or wire.

1878. E. G. BREWER. 4502.

(From T. A. Edison.)

Improvements in Lighting by Electricity.

Rendering incandescent metals having a high melting point, such as platinum, iridium, ruthinium, or other material mixed with magnesium or zincon oxides.

1878. H. W. TYLER. 4575.

Improvements in the Means or Apparatus for Electric Lighting.—(Provisional.)

Describes the use of various combinations of metals with refractory materials for incandescent lamps.

1878. ST. G. LANE-FOX. 4626.

See Lamps—Incandescent in Vacuum.

1878. J. T. SPRAGUE. 4662.

Improvements in Producing the Electric Light, and in Lamps applicable to that and other Sources of Illumination.

Uses fine carbon rods or other material, such as oxides, carbonates, sulphates, and silicates of the earthy metals, such as calcium, barium, and aluminium, made into a powder and mixed into a paste, with finely divided carbon or metals for incandescent lamps.

1878. SCOTT. 4671.

See Storage Batteries.

1878. A. M. THOMSON and H. D. EARL. 5281.

Improvemements in the Construction of Electric Lamps.

Describes the use of platinum or other electrodes enclosed in glass tubes, to prevent the burning part coming in contact with the air.

1878. EDISON. 5306.

See Machines—Miscellaneous.

1879. ST. G. LANE-FOX. 1122.

See Carbons combined with Non-Conductors.

1879. J. S. SELLON and H. EDMUNDS. 1791.

Improvements in Electric Lamps.—(Provisional.)

Renders incandescent a rod or wire of iridium; also describes holders or clips for same.

1880. **G. G. ANDRE.** 1507.

Improvements in Electric Lamps.

Describes a lamp where a piece of small-sized carbon is held between two holders and contained in an air-tight globe. Also describes an arrangement for allowing only a certain quantity of air to enter the globe as the carbon is consumed.

1880. **W. R. LAKE.** 1840.

(From T. L. CLINGMAN.)

Improvements in Apparatus for the Production of Electric Light.

Describes the use of a mass composed of the oxide of zirconia or a mixture of zirconia and plumbago or other form of oxide, which becomes incandescent on electric current being made to pass through it.

1881. **A. APPS.** 264.

Improvements in Apparatus for Producing Light by means of Electric Currents, etc.

Describes a form of lamp with a small carbon rod placed between two conductors, the whole being enclosed in an air-tight glass globe.

1881. **H. E. M. D. C. UPTON.** 1232.

Improvements in Electric Lamps.—(Provisional.)

The two carbons rest on two studs or rollers, and the ends become incandescent on the passage of current.

1881. **H. J. HADDAN.** 4305.

(From L. SOMZÉE.)

Improvements in Electric Lamps.—(Provisional.)

Describes the use of carbon pencils for incandescent lamps. A rod of refractory material is also used, at the circumference of which the light is produced.

1881. **A. F. ST. GEORGE.** 4939.

Improvements in Apparatus for Producing Light by means of Electricity.

Describes a carbon filament embedded in a composition of powdered flint mixed with silicate of sodium or other metallic silicate, or silicic acid and sufficient glycerine to form a paste; it is enclosed in a tube of powdered flint and water, vitrified; powdered carbon sometimes is mixed with the composition used.

XII. SEMI-INCANDESCENT.

1878. P. JENSEN. **4006.**

(From S. Marcus.)

Improvements in Electric Lighting Apparatus.

Describes a lamp having a carbon rod resting against the periphery of a carbon disc.

1878. B. P. STOCKMAN. **4315.**

Improvements in Apparatus for Producing Light by Electricity.—(Provisional.)

Describes a lamp with a carbon rod which is made to rise and press against a piece of carbon, by means of a float or buoyant support enclosed in a tube containing liquid.

1878. F. H. W. HIGGINS. **4456.**

Improvements in Apparatus for Producing, Maintaining, and Subdividing Electric Light.

Describes a lamp with a carbon rod which is made to rise and press against a piece of carbon by means of a float enclosed in a tube containing mercury. Arrangements are illustrated for allowing circulation of air around the carbons, to keep them cool.

1878. FRED. GYE. **4473.**

Improvements in Apparatus for Obtaining Electric Light..—(Provisional.)

Uses a revolving carbon disc as one electrode and a carbon stick as the other.

1878. J. H. JOHNSON. **5044.**

(From De Mersanne and E. Bertin.)

Improvements in Electric Lamps.—(Provisional.)

Describes a lamp with a carbon rod resting against a platinum wire.

1879. A. M. CLARK. **65.**

(From E. Ducretet.)

Improvements in Electric Lamps.—(Provisional.)

Describes a lamp with a carbon pencil enclosed in a tube containing mercury; the upper end of the pencil rests against a carbon block or other electrode.

1879. H. J. HADDAN. **299.**

(From E. Molera and J. Cebrian.)

Improvements in Apparatus for Producing Light by Electricity, etc.

Describes a lamp with a vertical carbon rod which is made to rise by being enclosed in a tube containing mercury, the upper end of the carbon pressing against a carbon block.

1879. **E. L. PARAIRE.** 325.

An Improvement in Electrical Light Apparatus.—(Provisional.)

Describes a lamp with a carbon rod raised by means of mercury contained in a cylinder. The upper end of the carbon rod is made to press against a carbon block.

1879. **R. W. H. PAGET HIGGS.** 454.

Improvements in Means and Appliances for Electric Lighting.—(Provisional.)

Describes a lamp with a vertical carbon rod with its lower end resting on a wedge-shaped block of carbon.

1879. **G. G. ANDRÉ.** 830.

Improvements in and connected with Electric Lamps.

Describes a lamp with a carbon rod resting on a piece of carbon, and contained in a glass globe for use in mines.

In another, the ends of two carbon electrodes rest on a non-combustible material.

A third is a lamp with circular carbon plates placed side by side.

1879. **R. WERDERMANN.** 2301.

Improvements in Apparatus for Electric Lighting.

Describes improvements in apparatus described in his Patent No. 2477, 21st June, 1878.

1879. **G. WHYTE.** 2744.

Improvements in the Construction and Action of Electric Lamps or Lights, or Mechanism connected therewith.

Describes use of circular carbon plates made to revolve by mechanism; also a lamp with one electrode consisting of carbon rod, and the other a revolving disc.

Also describes a lamp where the top carbon is secured by means of a clutch-lever, the bottom carbon being fitted to a holder fixed to an iron core in a solenoid.

1879. **F. J. CHEESBROUGH.** 3587.

(From W. E. Sawyer.)

Improvements in and relating to Electric Lamps, etc.

Rendering incandescent a small carbon pencil which is contained in a vessel with a carbon preservative atmosphere.

1879. **A. M. CLARK.** 3697.

(From J. M. A. Gerard-Lescuyer.)

Improvements in Electric Lamps or Regulators.

Describes a lamp where a disc or plate of carbon is used as one electrode, and a pencil of carbon as the other; this pencil is made to approach the plate of carbon by means of compressed air in a tube.

1879. **A. S. HICKLEY.** 4354.

Improvements in or applicable to Electric Lamps.

Describes a form of lamp where a carbon disc is made to turn so that a fresh surface is offered when an adjustment takes place. A pencil of carbon rises vertically as in Werdermann lamp, similar to Patent 4473, of 1878, F. Gye.

1879. **A. V. NEWTON.** 4405.

(From F. TOMMASI.)

Improvements in Electric Lamps.

Describes the use of a number of carbon rods or pencils floating in tubes containing mercury, and made to incline inwards towards a common centre and butt against a block of carbon.

1879. **A. JOEL.** 5157.

See Lamps, Arc—Vertical Carbons.

1879. **G. G. ANDRÉ.** 5206.

Improvements in and connected with Electric Lamps.

Describes a lamp with a carbon rod resting on a carbon block, and contained in an air-tight globe.

1880. **G. G. ANDRÉ and E. EASTON** 2252.

Improvements in Electric Lamps.

Describes a lamp with a carbon rod made to rise and press against another electrode ; it is raised by means of a cord with a weight attached to same. The whole is contained within a globe kept air-tight, except when the lamp is not burning, an aperture being then opened to allow of free access of air.

1880. **G. G. ANDRÉ.** 2764.

Improvements in and connected with Electric Lamps.

Describes the use of a small motor for regulating the burning of the electrode in arc and semi-incandescent lamps.

1881. **COMMON and JOEL.** 1040.

See Lamps, Arc—Vertical Carbons.

1881. **COMMON and JOEL.** 1040.

See Lamps—Vertical Carbons.

1881. **R. HARRISON and C. BLAGBURN.** 1358.

Improvements in Electric Lamps.

Describes a lamp where a carbon rod is made to press against a block by means of weights.

1881. **JOHNSON.** 1653.

See Lamps—Incandescent in Vacuum.

1881. **J. B. ROGERS.** 4855.

Improvements in Electric Lamps.

Describes a lamp with the lower electrode consisting of a block of carbon with a centre core of refractory material which is raised upwards by means of a weight. The upper carbon is attached to a cross-arm which is fitted to a metal rod, and is arranged so that the carbon rod can be placed over the refractory material or the carbon of bottom electrode.

Also describes a lamp with carbons inverted, with their ends resting on a refractory material.

XIII. MISCELLANEOUS.

1880. **J. H. GUEST.** 925.

Improvements in Electric Lamps.

Describes the use of a strand of wires for the conductors, sealed in the glass, with two enlargements containing mercury around same. The incandescent carbon is hung in loops made at the ends of the strand conductors; at the side of the globe is a chamber which contains spare carbons, which are arranged to pass into the loops in case one fails.

1881. **J. E. H. GORDON.** 218.

Improvements in Apparatus for Producing Electric Light.

Describes two balls of a refractory metal placed in hydrogen or nitrogen at a pressure of $\frac{1}{3}$ to $\frac{1}{2}$ an atmosphere, the light being produced by the discharge of high tension alternating currents between the balls, being an improvement on lamp described in his patent of 1880, No. 1826.

1881. **P. JENSEN.** 1802.

(From T. A. Edison.)

Improvements in Electric Lights and Fittings and Fixtures therefor.

Describes various forms of sockets to hold incandescent lamps and other details in fixtures.

1881. **C. H. GIMINGHAM.** 2079.

Improvements in the Construction of Electric Lamps, and in Sealing Electrical Conductors into Air-tight Receivers.—(Provisional.)

Describes conducting wires sealed in glass stems ground to fit the glass globe, and filling up space with a vacuum cement made of beeswax and resin.

1881. **Dr. GRAHAM.** 3073.

Improvements in Lamp Casings or Holders for Containing and Protecting Electric Lamps, etc.

Describes a case for containing lamps for miners, with bars and lock; use of contact-makers for same, covered with oil or water, or contained in a sealed tube.

1881. F. H. F. ENGEL. **3711.**

(From C. H. F. Muller.)

Improvements in Electric Lamps.—(Provisional.)

Describes the use of plates instead of wire for conductors for incandescent vacuum lamps.

1881. E. G. BREWER. **4174.**

(From T. A. Edison.)

Improvements in Electric Lamps and the Manufacture thereof.

Describes details of socket for lamp, and sundry details of manufacture; coating junction of filament and conductors by electro deposit, etc.

1881. C. H. GIMINGHAM. **4193.**

Improvements in Electric Lamps.

Describes the flattening of the ends of platinum conducting wire and forming it into a tube and then clamping the ends of filament on same.

1881. A. G. SCHAEFFER. **4294.**

Improvements in the Manufacture of Incandescent Electric Lamps.

The glass holding the conducting wires and filaments is sealed to the globe before the air is exhausted, one of the conductors holding the filament being made of a platinum tube, and the air exhausted through the hole, and the tube closed.

1881. R. H. COURTENAY. **4659.**

Improvements in Lighting by Gas and Electricity combined.

Describes the placing of a piece of platino-iridium wire, rendered more or less incandescent by an electric current, in the upper fringe of the flame of a batswing burner.

Also describes arranging for a passage for gas in a Jablochkoff candle.

1882. J. N. ARONSON. **305.**

Improvements in Electric Lamps.

Glass globes are made with reflectors in or on the globes.

Also describes using prisms or lenses forming part of the globe.

1882. F. WRIGHT and W. W. MACKIE. **1029.**

Improvement in Incandescent Electric Lamps.

The conducting wires are fixed on to a tube of glass by means of spun glass, and the bulb is then sealed to same, the air being exhausted by means of the tube.

Also describes the ends of the filament secured to the split ends of the conducting wires by means of a ring of steatite.

SUBDIVISION III.

ELECTRODES.

I. FOR ARC LAMPS.

1878. A. H. P. STUART-WORTLEY. **3656.**

Improvements in the Manufacture of Electrodes for Electric Lighting, etc.

Describes electrodes made of mixtures of carbon and highly refractory materials. Also describes the covering of each of the carbon points with a hood or covering of asbestos or other like material.

1878. F. H. VARLEY. **4100.**

Improved Means of Producing Electricity and the Electric Light.

Describes the use of a stream or layer of finely powdered graphite or carbon, which is constantly renewed as the requirements of the light necessitates.

1878. C. W. HARRISON. **4338.**

Improvements in Obtaining Light by Electricity, and in the Means or Apparatus employed therein.—(Provisional.)

In place of ordinary electrodes, a fluid or temporary conductor is used. Conductivity is broken by vibratory motion, causing flashes sufficiently rapid to produce the effect of a continuous and uniform light.

1878. M. GRAY. **4553.**

Improved Mode of Manufacturing Carbons for Electrical Purposes.

Describes the use of powdered carbon washed in acid or alkaline solution to remove impurities, then mixed with sugar, molasses, or other suitable substance, the mixture being then pressed through dies.

1878. J. S. SELLON, W. LADD, and H. EDMUNDS. **4645.**

Improved Means for Obtaining Electric Light.

Iridium in a pure state is used as one electrode, and a carbon rod as the other, the iridium point being practically permanent.

1878. COHNÉ. **5011.**

See Carbons combined with Non-Conductors.

1878. **R. PUNSHON.** 5105.

Improved Carbon Points or Candles for the Production of the Electric Light, etc.

Describes the use of a mixture of carbon powder, asbestos powder, and an amalgam of mercury. Albumen, gum, and treacle is then added, and the whole is subjected to great pressure and made the desired shape.

1878. **A. M. CLARK.** 5165.

(From L. Regnard.)

Improvements in Electric Lamps.—(Provisional.)

Describes making or moulding on the carbons a screw or thread or rack so that the carbon will form part of mechanism of lamp.

1879. **S. COHNÉ.** 277.

A New and Improved Electric Candle for the purpose of Lighting by Electricity and effecting Divisibility of Electric Light.

Describes the manufacture of electrodes by mixing ultramarine with finely-divided carbon.

1879. **J. B. SPENCE.** 876.

Improvements in the Mode of and Apparatus for Producing Light by Electricity. (Provisional.)

Describes using electrodes of metal tipped with platinum.

Also describes the use of gas combined with electricity.

1879. **R. C. THOMSON.** 927.

Improvement on the Means employed in Producing the Electric Light.—(Provisional.)

Describes the use of powdered carbon or other suitable material in lieu of solid carbon rods. Powdered carbon can be contained in carbon or other tubes operated by suitable mechanism.

1879. **R. C. THOMSON.** 1622.

Improvements in Means employed in Producing the Electric Light—(Provisional.)

Describes use of powdered carbon in lieu of the ordinary solid carbon, being improvements on Patent No. 927, of 1879.

1879. **J. FURSTENHAGEN.** 2199.

(From Gebruder, Siemens, & Co.)

Improvements in Lighting by Electricity.—(Provisional.)

Describes the manufacture of carbon electrodes, round or prismatic shaped, with a core of glass or other vitreous substance.

1879. **A. M. CLARK.** 2340.

(From C. J. P. Desnos.)

Improvements in Electrodes used in the Production of the Electric Light.—(Provisional.)

Describes the placing of a rod of iron or other metal in the middle of a cylinder of carbon.

1879. F. J. DE HAMEL. 2543.

Improvements in the Manufacture of Carbon Candles or Points, and of Carbon Plates for Electric Lighting and other purposes.

Inserting or embedding in carbon rods one or more iron wires, or surrounding surface of carbon with same.

1879. W. M. BROWN. 3355.

(From P. A. Porlier.)

Improvements in the Manufacture of Electrodes for the Production of Electric Light.

Describes the use of steel tubes, within which is compressed a powder or paste of one or more of the oxides capable of acting as a base to the metallic oxide produced by the combustion of the metallic tube.

1879. C. W. HARRISON. 3875.

Improvements in Electric Lighting, and in Means or Apparatus employed therein.

Describes the manufacture of carbon electrodes of pure lamp-black and naphthaline dissolved in boiling tar. This is then kneaded together, so that it will cohere when pressed. Powerful pressure is then applied, and burnt at a high temperature for some hours.

Also describes a form of lamp where the mechanism for regulating the burning of the electrodes is regulated by the deflection of a magnet within a coil of wire.

Also describes use of carbon discs or plates placed side by side each other.

1880. HEINRICHS. 4608.

See Dynamo Machines—Gramme type.

1881. R. WERDERMANN. 304.

Improvements in the Manufacture of Carbon, etc.

Sugar is carbonised either by heat or by the action of sulphuric acid or hydrochloric acid. Also describes the making of a mixture of sugar with essences, oils, resin, tar, or other substances, which, when decomposed by heat, leave a residuum of pure or nearly pure carbon; it is then made into a paste with sugar, etc., and pressed or moulded into shape.

1881. WALLER. 803.

See Machines—Siemens type.

1881. H. J. HADDAN. 1852.

(From L. Somzèe.)

Improvements in Electric Lighting, and in Apparatus therefor.—(Provisional.)

Describes the passing of an electric current through a gas flame.

Also describes the use of powdered coal mingled with particles of magnetic metal, soft iron, etc., for electric light.

1881. J. G. LORRAIN. 2848.

Improvement in Treatment of Carbon for Electric Light and other purposes.

Describes carbon rods, filaments, etc., combined with a substance containing carbon in conjunction with a substance that will be acted on by carbon, so that decomposition shall take place, and carbon be deposited in or on the substance.

1881. J. H. JOHNSON. 3402.

(From J. B. J. MIGNON and S. H. ROUART.)

Improvements in Electrical Lamps and in Manufacture of Carbons, etc.

Describes carbons made with a wick or core, and also coating the carbons with enamel or glass.

1881. J. JAMES and J. C. F. LEE. 4396.

Improvements in the Manufacture of Carbons for Electric Lamps, etc.—(Provisional.)

Describes electrodes made of carbonaceous material reduced to a fine powder, and then placed in an hydraulic press and moulded into shape.

Also describes the manufacture of carbon serrated on one side.

1882. W. R. LAKE. 224.

(From J. S. WILLIAMS.)

Improvements in and relating to Electric Lighting Apparatus, etc.

Describes the manufacture of electrodes by depositing a metal or metallic alloy on an earthy material.

1882. MILLS. 578.

See Lamps, Arc—Vertical Carbons.

II. FOR INCANDESCENT LAMPS.

1878. A. S. HICKLEY. 4132.

Improvements in or applicable to Electric Lighting Apparatus.—(Provisional.)

In this lamp the carbons, which are contained in tubes, are placed at an angle, and made to rise upward by means of springs pressing against their ends. The upper ends of the carbon rods press against a block of compressed manganese, lime, chalk, or other substance capable of becoming incandescent.

1878. ST. G. LANE-FOX. 4626.

See Lamps—Incandescent in Vacuum.

1878. SPRAGUE. 4662.

See Lamps—Incandescent without Vacuum.

1878. SCOTT. 4671.

See Storage.

1878. **CHEESBROUGH.** 4847.

See Lamps—Incandescent in Vacuum.

1879. **ST. G. LANE-FOX.** 1122.

See Carbons combined with Non-Conductors.

1879. **EDISON.** 5127.

See Lamps—Incandescent in Vacuum.

1880. **J. CLARK.** 203.

Improved Apparatus for Developing the Electric Light.

Describes the filaments of a compound of asbestos, paper, etc., which, after carbonising or charring same, are placed in a globe containing carbonic gas or made air-tight.

1880. **MAXIM.** 1649.

See Lamps—Incandescent in Vacuum.

1880. **SWAN.** 5014.

See Lamps—Incandescent in Vacuum.

1880. **FITZGERALD.** 5272.

See Lamps—Incandescent in Vacuum.

1881. **P. JENSEN.** 562.

(From T. A. Edison.)

Improvements in Carbon Burners for Incandescent Electric Lamps and in Manufacture thereof, etc.

Describes filaments made by precipitating carbon from a gas or vapour on to sheets of nickel or cobalt heated to a high temperature; the metal plates are removed from the carbon by dissolving them in acid. After the filament is placed in the globe, the air is exhausted while the current is passing through the filament, etc.

1881. **W. R. LAKE.** 639.

(From H. S. Maxim.)

An Improved Method of Preparing Carbon for Electric Lighting.

The carbon filaments are placed in pure hydro-carbon or other carbonaceous gas, in a pressure equal to one inch of mercury; a current is sent through the filament to increase the temperature, and separate the elements of the gas. The carbon set free is deposited in a state of fine subdivision in the pores and upon the exterior of the carbon, thereby reducing the resistance and changing its illuminating capacity.

1881. **J. SCOTT and W. H. AKESTER.** 1412

Improvements in the Manufacture of Carbons for Incandescent Electric Lamps.

Describes using a fibre called "Kitool" or coir or bass.

1881. **W. CROOKES.** 1422.

Improvements relating to the Production of Electric Light.

Describes a means of removing the inorganic constituents of the cellulose from carbon filaments, by the action of dilute hydrochloric or other suitable acid. Same result also can be obtained by heating to whiteness in an atmosphere of free chlorine.

1881. **E. G. BREWER.** 1918.

(From T. A. Edison.)

Improvements in the Manufacture of Carbon Conductors for Incandescent Electric Lamps.

Describes the manufacture of filaments of graphite or plumbago, graphotoidal silicon, boron zirconium, and the like. The material used is reduced to powder pressed into sheets by means of a die; when the substances do not cohere they are made into a paste by a fluid having hydro-carbon in solution.

1881. **W. CROOKES.** 2304.

Improvements in the Manufacture of Apparatus for the Exhibition of Electric Light.

Deposits metal on to and in the pores of the carbon filament, also on and at the ends of the conducting wires.

1881. **W. CROOKES.** 2612.

Improvements in the Construction of Lamps, etc.

Uses linen, paper, etc., purified from silica by hydroflouric acid, and treated with a solution of cupro-ammonia; after the ammonia is evaporated and the copper extracted, the cellulose assumes a dense form. Other methods are described. The filaments are carbonised. If the filament is not of the required resistance, it is heated electrically in a vacuous vessel which contains a hydro-carbon compound.

1881. **R. H. COURTENAY.** 2770.

Improvements in Electrical Resistance Mediums, more particularly adapted for use in Vacuum and other Electric Lamps and Tubes.—(Provisional.)

The filaments are formed by rubbing a silk thread with saccharine matter, then with plumbago and asbestos.

Also describes carbonising date fruit and stones and cloth, and mixing them with asbestos and cotton carbon powder, and rolling the mass into threads.

1881. **G. G. ANDRÉ and E. EASTON.** 2833.

Improvements in Electric Incandescent Lamps and in Burners for same.
(Provisional.)

Describes making filaments from natural products and carbonising.

1881. **LORRAIN.** 2848.

See Electrodes for Arc.

1881. **ST. GEORGE LANE-FOX.** 3122.

Improvements in the Manufacture of Electric Bridges for Lamps.

Describes the use of certain grasses, and more particularly a fibre known as French whisk, for bridges of incandescent lamps. The fibres are boiled in caustic soda and potash, the outer skin cleared off and boiled in water till all trace of soda is removed. The filaments are afterwards carbonised.

1881. **PFANNKUCHE.** 3650.

See Carbons combined with Non-Conductors.

1881. **FAURE.** 4311.

See Lamps—Incandescent in Vacuum.

1881. **ST. G. LANE-FOX.** 4383.

Improvements in the Manufacture of Electric Bridges for Incandescent Lamps, and in the Means employed therein.

Describes the use of a series of bottles containing hydro-carbon gas or vapour, into which the filament is placed and electrically connected to a resistance-measuring apparatus. When the proper resistance is obtained the filaments are removed from the bottles.

1881. **R. HARRISON.** 4478.

Improvements in Electric Lamps.

Uses thick paper for the filament, and describes an automatic shunt, by which one lamp takes the place of another in case of extinction.

1881. **G. G. ANDRÉ.** 4654.

Improvements in and connected with Electric Incandescent Lamps.

The filaments are made of a vegetable fibre, such as rattan. They are immersed in a mixture of sulphuric acid (four parts) and nitric acid (one part). After washing, they are steeped in a solution of nitro-cellulose, in ether, or other solvent; when dry they are carbonised, and treated in ether, tar, boiled linseed or other drying oil, sugar, syrup, solution of starch, dextrine, and the like, to fill up the pores; the filaments are again carbonised.

1881. **C. J. ALLPORT and R. PUNSHON.** 4850.

Improvements in the Manufacture of Carbons to be employed for the Production of Electric Light.

The filaments of incandescent lamps consist of a thread of asbestos soaked in a solution of sugar or syrup, and carbonising it.

1881. **KENNEDY.** 5524.

See Lamps—Incandescent in Vacuum.

1881. A. R. SENNETT. 5286.

Improvements relating to the Production of the Electric Light in Electric Lamps, and in the Means for and Method of Manufacture of the Carbons and Incandescing Conductors for the same.

Describes the use of materials such as linen cuttings, cotton, cotton wool, etc., rich in cellulose; reducing same to a pulp, by means of solvents. It is then passed through a porous diaphragm, and is deposited upon another diaphragm. It is afterwards moulded under high pressure and carbonised by a vapour of bisulphide of carbon or other suitable vapour and placed in a globe and the air exhausted.

SUBDIVISION IV.

STORAGE BATTERIES.

1878. J. S. WILSON. 4348.

Improvements in and appertaining to Secondary Batteries.—(Provisional.)

Uses iron for cathode and anode, and saturated solution of one or more certain salts rich in oxygen.

1878. W. L. SCOTT. 4671.

Improvement in the Production, Regulation, and Distribution of Electric and Electro-Calcic Lights.

Describes the use of condensers, preferably made of thin sheet copper, the surfaces of which are equivalent to 1¼ the surfaces of the conducting wires.

Also describes method of rendering incandescent, various oxides, etc., of earthy metals.

1878. G. E. DERING. 5123.

Improved Means of Obtaining Light, Heat, and Motive Power.

Uses the current generated by dynamo machines (when not used for giving light) to decompose water and store the resistant gases, oxygen and hydrogen, under pressure, in suitable holders. These gases can then be burnt together, so as to produce what is known as lime light.

1880. P. JENSEN. 3025.

(From M. Avenarius.)

An Improved Method of Electric Lighting, ensuring the Independence of Separate Burners.

Describes a system of electric lighting with secondary (derived or shunt) circuits containing electrolytic apparatus.

1881. **J. H. JOHNSON.** 129.
(From C. FAURE.)

Improvements in Galvanic Polarisation, Batteries or Magazines of Electricity and the Application of the same, and in Apparatus connected therewith.

Deposits on lead plates a layer of spongy or porous lead in the following manner:—The plates are coated with metallic salts or oxides mixed with *inert* substances, such as lead sulphate mixed with pulverised coke; the two elements thus prepared are immersed in a solution of dilute sulphuric acid, and on passing a current through them the salt on one of them will be reduced and form an adhesive porous coating, and on reversing the current the action on the other plate will be the same, and the first plate will be re-oxidised or peroxidised, and the two elements thus form a galvanic couple.

1881. **J. H. JOHNSON.** 1097.
(From LA SOCIÉTÉ ANONYME LA FORCE ET LA LUMIÈRE SOCIÉTÉ GÉNERALÉ D'ÉLECTRICITÉ.)

Improvements in Voltaic Batteries, which Improvements are also applicable to Secondary Batteries.

Electrodes are made cone-shaped; a number are placed one within the other, the smaller part of the cones being placed downwards.

1881. **J. H. JOHNSON.** 1676.
(From C. A. FAURE.)

Improvements in Secondary Electric or Galvanic Batteries.

Describes improvements in means of supporting the active substance in Faure's battery, as described in his specification 129 and 1097, 1881.

Also describes the use of cone-shaped cells packed one within the other.

1881. **C. DABEL.** 1745.
(From P. JABLOCHKOFF.)

Improvements in Electrical Batteries.—(Provisional.)

Describes the use of spirally-wound plates of metal immersed in an acting substance of an oily or resinous nature.

1881. **J. W. SWAN.** 2272.

Improvements in Secondary Batteries or Apparatus for Storing or Conserving Electricity.

Uses plates having cellular, corrugated, or grooved surfaces, thereby exposing a large surface to be acted on.

1881. **J. H. JOHNSON.** 2323.
(From LA SOCIÉTÉ LA FORCE ET LA LUMIÈRE SOCIÉTÉ GÉNÉRALE D'ÉLECTRICITÉ.)

Improvements in Secondary Electric Batteries.—(Provisional.)

Describes a form of battery where sheets of metal forming the negative electrodes, are folded in sheets of felt or other porous material; on the exterior plates are placed capable of acting as the positive electrode.

1881. **A. MUIRHEAD.** **2606.**

Improvements in Electric Accumulators or Secondary Batteries.—(Provisional.)

Uses thin sheets of metal separated by a permeable material, and the plates arranged similarly to a condenser. The sheets are coated with sesquioxide and red oxide of lead, or red oxide of lead and peroxide of manganese only, or acetate or nitrate of lead.

1881. **H. E. NEWTON.** **2782.**

(From Société Universelle d'Électricité Tommasi.)

Improvements in Secondary Batteries.

Uses flanged lead plates placed slantwise, the spaces between the shelves being filled with finely-divided lead.

1881. **A. P. LAURIE.** **2823.**

Improvements in Secondary Batteries.—(Provisional.)

Describes a battery with plates of zinc and carbon in a solution of iodide of zinc. Zinc is deposited on the zinc plate, and iodine is set free at the carbon when a current is sent through.

1881. **Sir W. THOMSON.** **3032.**

(*See* Subdivision VI., No. I.)

1881. **J. S. SELLON.** **3926.**

Improvements in Secondary Batteries or Magazines of Electricity.

Describes the use of perforated plates or sheets, roughened, serrated, or indented, composed of lead, platinum, or carbon, upon or against spongy or finely-divided lead or oxides.

1881. **J. S. SELLON.** **3987.**

Improvements in Secondary Batteries or Magazines of Electricity.

Describes using plates or elements composed of alloys of lead with antimony; also the use of perforated strips, tubes, pieces, or woven fabrics of lead or of the above alloy.

1881. **J. S. SELLON.** **4005.**

Improvements in Storing Electricity.

Uses positive poles of sheets, foil, gauze, wires, pieces, or any form of suitable metal or carbon, and immersing same into suitable metallic salts and deposits from such salt, their oxides.

1881. **W. CLARK.** **4037.**

(From N. De Kabath.)

Improvements in Secondary Batteries.

Describes the use of a composite electrode consisting of thin corrugated sheets of lead folded around a thicker sheet forming a support, and enveloped by a sheet of parchment paper.

1881. **A. M. CLARK.** 4060.

(From N. De Kabath.)

Improvements in Regulating the Discharge of Secondary and other Batteries.

Regulates the discharge by varying the height of the liquid or other conductor which closes the internal circuit.

1881. **A. WATT.** 4255.

Improvements in Secondary Galvanic Batteries or Electrical Accumulators.

Describes coating two or more plates of lead with a mixture of manganese dioxide, calcium hydrate, and sodium chloride or manganese hydrate, calcium hydrate, and calcium chloride, known as Weldon mud, mixed with powdered carbon or coke.

1881. **A. P. LAURIE.** 4310.

Improvements in Secondary Batteries.

Describes a form of battery the essential feature of which, is the storing of chlorine, and which consists of either two copper plates or one plate of zinc or other suitable metal, and one copper plate immersed in a solution of chloride of zinc or other chloride.

1881. **A. W. L. REDDIE.** 4398.

(From E. Volckmar.)

Improvements in the Construction of Secondary Batteries or Electrical Accumulators. (Provisional.)

Two reticulated or perforated plates of lead are prepared, and the spaces filled with granules of lead. The plates are then submitted to pressure and placed together, with strips of non-conducting material placed between them; they are afterwards placed in a bath of acidulated water.

1881. **J. W. SWAN.** 4455.

Improvements in the Construction of Secondary Batteries or Apparatus for effecting Electrical Storage.

Describes the extending of the surface of the lead plates by cutting or scraping or similarly acting on them, so as to facilitate the storing action.

1881. **J. H. JOHNSON.** 4508.

(From E. U. Parod.)

Improvements in or connected with Apparatus or Means for the Production, Collection, or Storage, etc., of Electricity.—(Provisional.)

Describes using in combination with the condensing conductors described in Letters Patent 4686, of 1878, of accumulators, etc., to collect and store up electricity generated in excess.

Also describes using condensers of all descriptions for transporting electricity to a distance, in lieu of wires or cables.

1881. **P. JENSEN.** 4553.

(From T. A. Edison.)

Improvements in Method and Means for Charging and Using Secondary Batteries.

Describes a means for maintaining the electro-motive force of a current from secondary batteries, by reinforcing the primary current from time to time, so as to keep up the force in the main or consumption circuit.

1881. **J. T. SELLON.** 4632.

Improvements in the Construction of Secondary Batteries.—(Provisional.)

Pieces of metal, such as platinum, in the form of gauze or sheet, plain or corrugated, or carbon, are used with peroxide of lead packed round same; sheets of porous material are placed round the peroxide to form cells, lead plates being used as the other electrode; both electrodes are placed in acidulated water.

1881. **A. M. CLARK.** 5104.

(From G. Fournier.)

Improvements in Electric Batteries.

Describes the use of a mixture of glycerine or glyceric acid, and of metallic oxides capable of forming a solid compound insoluble in water. Plates formed as described are used as one of the elements. If oxide of lead is used in the mixture and zinc is used as the other element, the hydrogen reduces the lead as fast as it is evolved and no polarisation occurs. By using peroxides greater effects are produced.

Also describes a secondary battery of one plate oxide, peroxide, and glycerine, and the other of lead oxide, metallic lead in powder, and glycerine.

1881. **R. E. B. CROMPTON and D. G. FITZGERALD.** 5159.

Improvements in Galvanic Batteries and Electro-Chemical Accumulators.

Describes a porous electrode offering large surface.

Also describes the preparation of porous electrodes by the removal through electrolysis of zinc, sodium, potassium, iron, cadmium, antimony, copper, or silver from alloys or mixtures of one or more of these metals with lead.

1881. **C. H. W. BIGGS and W. W. BEAUMONT.** 5198.

Improvements in Apparatus or Secondary Batteries, etc., etc.

Describes a method of preventing the loss of the products in charging secondary batteries, by the use of cells having gas and liquid-tight holders, made of flat porous lead electrodes made by compressing finely-divided, and preferably partially-oxidised, lead alone, made into cakes or plates, etc.

1881. **H. E. NEWTON.** 5261.

(From E. Volckmar.)

Improvements in the Construction of Secondary Batteries.

Describes the placing of the electrodes horizontally one above the other,

which is the most favourable condition for charging the hydrogen disengaged from the positive electrode, which will rise to the negative electrode, and the oxygen will descend from the negative to the positive, in accordance with the law of densities.

1881. **J. IMRAY.** **5322.**

(From J. CARPENTIER and O. DE PEZZER.)

Improvements in Electric Accumulators.—(Provisional.)

Makes the negative plate very thin, and the positive plate double the area and twice the thickness of the negative plate.

1881. **D. G. FITZGERALD, C. H. W. BIGGS, and W. W. BEAUMONT.** **5338.**

Improvements in Secondary Batteries.

Describes method of making porous electrodes by minutely puncturing the surface of the sheets of lead, then immersing the plates in sulphuric acid and depositing lead sulphate on them, and afterwards rolling them thinner, so as to extend their surface, and again puncturing them. Also deposits lead on a fine net fabric, which is folded to make up any thickness required.

1881. **J. PITKIN.** **5451.**

Improvements in Secondary Batteries.

Forms the electrodes of a mass of very thin turnings or shavings of lead, or strips, etc., of lead foil, or highly laminated sheets of leads in a crumpled condition, and placed in a suitable open frame having a covering of felt, and afterwards placed in a vessel containing acidulated water. Uses in combination with the above, red lead, litharge, or other lead oxide or salt of lead.

1881. **D. G. FITZGERALD.** **5481.**

Improvements in Secondary Batteries.

Uses carbon, in conjunction with lead or compounds of lead, for the electrodes. These consist of plates of carbon with perforations and are filled with lead in a state of fine division, or any suitable compound of lead.

Also describes the use of a tube of carbons filled with the lead, etc.

1881. **J. W. SWAN.** **5494.**

Improvements in Secondary Voltaic Cells.

In this battery the plates of lead used in the battery described in Patent 2272, of 1881, are exposed to the combined action of acetid acid, carbonic acid, and atmospheric air, for the purpose of forming carbonate of lead on the plates. The carbonate of lead on the plates are subjected to action of electrolytic hydrogen, to transform it into metallic lead; the plates are then arranged in a vessel.

1881. **G. GROUT and W. H. JONES.** 5521.

Improvements in Secondary or Polarisation Batteries for the Storage of Electrical Energy.

Uses lead plates combined with carbon, as follows:—Flour, starch, or meal of any kind is reduced to a powder and mixed with the oxide of salt or lead or other metal, and is made into a plastic mass by mixing with oil, etc., and then moulded and dried in a vessel containing powdered carbon, to prevent contact with the atmosphere. The whole is then exposed to a gentle red heat, to carbonise and reduce the oxide or salt to the metallic state within the pores of the carbon.

1881. **J. S. SELLON.** 5631.

Improvements in the Construction of Secondary Batteries.

In this battery the plates, terminals, and supports, etc., employed in secondary batteries are made of a material not readily subject to destruction by oxidation. Carbon in a solid form or combined with other substances, may be used for the purpose.

1882. **D. G. FITZGERALD, C. H. BIGGS, and W. W. BEAUMONT.** 29.

Improvements in Secondary Batteries.

Uses as an electrode the chemical action which occurs between lead and a metal electro-negative to lead.

Also uses as an electrolyte a solution of plumbic sulphate in ammoniac sulphate.

1882. **R. KENNEDY.** 72.

Improvements in Secondary or Reversible Electric Batteries.

Describes the use of a plate of lead coated with a layer of lead peroxide or dioxide, and immersed in dilute acid, over which another sheet of lead is suspended, and when the current is sent through them a close-grained, spongy lead is deposited on the lower plate; this lower plate is then cut up and painted with lead dioxide, obtained by passing chlorine through lead monoxide, and made into a paste with water and glycerine. The upper plate is cut up and painted with a paste of water, glycerine, lead, dioxide, and lead sulphate. The two sets of plates form the elements of the battery.

1882. **J. E. LIARDET and T. TONNITHORNE.** 120.

Improvements in the Means of and Apparatus for Storing Electrical Energy, etc.

Describes cells having various combinations of lead, viz.:—1st, lead shot; 2nd, hollow lead balls; 3rd, broken charcoal, coke, asbestos, etc., coated with metallic lead. Also uses lead deposited from a salt of the metal, such as acetate, by means of zinc. Also lead plates attached to compressed plates or cakes of red lead. Also finely-divided porous lead. Porous lead may be obtained direct from lead ore by dissolving the ore in acid, and precipitating the metal by zinc.

1882. H. J. HADDAN. 144.

(From E. Boettcher.)

Improvements in Secondary Galvanic Batteries.

Decomposes a solution of pure sulphate of zinc and thereby deposits zinc on a thin plate of sheet zinc, and uses a folded lead plate coated with an emulsion of a solution of pure litharge prepared with the zinc solution.

The oxygen comes in contact with the lead plate, and forms on its surface a thin layer of peroxide; on the electrodes being joined the previously deposited zinc is redissolved, and the original sulphate of zinc produced, while the hydrogen reduces into finely-divided lead, not only the peroxide, but also a part of the lead plate. Several repetitions of this process render the cell ready for use.

1882. H. J. HADDEN. 185.

(From A. Morel.)

Improvements in Electric Accumulators.

Describes an arrangement similar to Groves' gas battery.

1882. H. H. LAKE. 252.

(From La Société Universelle d'Électricité Tommasi.)

Improvements in and relating to Electric Accumulators or Secondary Batteries.

Describes a battery with folded sheets of lead. Between the folds is placed a sheet of lead with lead wire wound on it; the plates are perforated to allow of circulation of liquid.

1882. J. HUMPHRYS. 289.

Improvements in Secondary Batteries for the Storage of Electricity.

Describes a battery where lead plates are made with bars arranged as in a Venetian blind, thereby exposing a great surface of lead to the action of the liquid. Oval section, also diamond shaped bars are shown.

1882. J. S. SELLON. 319.

Improvements in the Construction of Secondary Batteries.

Describes the supports, frames, or retainers on which the active material is deposited, either wholly or partially of pieces of metal, carbon, or other suitable material.

1882. W. R. LAKE. 538.

(From J. J. Barrier and F. T. De la Vernede.)

Improvements in Electric Accumulators or Secondary Batteries.

Uses lead ribbon, the surfaces of which are separated by a cement consisting of one part platinised charcoal, one part litharge, and one part glycerine. The ribbon is wound in several forms.

1882. J. S. WILLIAMS. 700.

Improvements in and relating to the Generation, Storage, etc., of Electricity.

Describes the use of thermo-electric generators for producing light, etc.,

and prefers using as a base, metals such as iron or steel (wrought or cast), and used in combination with some other metals such as copper, or some alloy with copper, etc. Proposes using the thermo-electric generators on a large scale; also describes storage batteries or accumulators in connection with same, and distributing the electricity from them.

1882. J. S. WILLIAMS. 766.

Improvements in and relating to the Generation, Storage, Distribution, etc., of Electricity.

Uses a tank or reservoir filled with metallic salts or oxides of spongy lead, or employs other means for conserving and storing electrical energy. Wires or conductors are led from this tank.

1882. J. L. PULVERMACHER. 837.

Improvements in Apparatus for Collecting and Storing Electric Currents. (Provisional.)

Describes the use of platinum electrodes, coated with platinum sponge or sponge black, or oxide of lead. The plates are arranged in a vessel capable of withstanding great atmospheric pressure. Owing to the atmospheric pressure in the vessel, the charge is greatly increased.

1882. J. S. WILLIAMS. 856.

Improvements in and relating to the Generation, Storage, Distribution, and Utilisation of Electricity, and Apparatus or Means therefor.

Describes a system of lighting, storing, and applying electricity to railway trains. Also the use of secondary battery in connection with an incandescent lamp for table lamps and chandeliers.

1882. J. SWAN. 905.

Improvements in Secondary Batteries.

Uses galena or sulphide of lead in a finely-divided condition, and reduced to a metallic state by the action upon it, of hydrogen evolved by electro-chemical action or chemical action. The finely-divided lead thus produced, is applied to the pole plates of a Planté's cell, to facilitate the formation of oxide of lead.

1882. S. COHNÉ. 1437.

Improved Electric Accumulators for the Storage of Electric Energy.

Applies on sheets of lead a layer of mercuric sulphide (Hg. S.), as cinnabar or vermilion. Two sheets are placed in a cell in dilute sulphuric acid; when current enters, hydrogen is liberated and reduces the mercuric sulphide, causing a deposition of metallic mercury on the surface of the lead. When the effects of polarisation are manifest local action disappears; the amalgam formed, without being destructive to the lead, decomposes the water, and in that way hydrogen is always conserved and travels backwards and forwards as the cells are charged and discharged; peroxide of lead is thus formed, the percipulated sulphur acting as a resistance. Sulphate of mercury (Hg^2 OS O^3) can be used in place of above.

SUBDIVISION V.

SUBDIVISION OF THE CURRENT.

1878. J. CLARK. 3991.

A New or Improved Method of Adapting the Electric Light to Domestic and other ordinary purposes.

Two wires are taken from the machine to two baths of mercury, and then a number of wires or leads are taken from the two baths of mercury. Proposes the use of finely-divided carbon or other suitable material placed between pieces of glass for producing light.

Also describes the use of asbestos, chromate of potash, or bichromate of potash.

1878. J. MUNRO. 4016.

Improvements in Electric Lighting, Heating, and Motive-power Apparatus. (Provisional.)

A wheel having a number of insulated conducting pieces attached, are made to press by means of springs, against contact-pieces which are connected to their respective wires.

Also describes an oscillating lever moving over contact-studs.

1878. A. ARNAUD. 4074.

A Mode of Indefinitely Dividing Electric Currents.

The work to be done in the circuit is placed in connection with the poles of the machine.

1878. E. J. C. WELCH. 4114.

Improvements in the Method of Dealing with Electric Currents, etc.

Describes an arrangement whereby a number of contacts are brought into electrical connection by means of a revolving wheel or drum.

1878. C. T. BRIGHT. 4212.

Improvements in Lighting by Electricity.—(Provisional.)

Describes the use of a number of induction coils in the main circuit, the primary wires of which are connected to the main wire from machine; the secondary wires are connected to tubes containing rarified gases, etc.

1878. C. E. SHEA. 4304.

A Method of Dividing and Distributing the Current produced by Galvanic Batteries and Magneto- and Dynamo-Electric Machines, etc.—(Provisional.)

Two wheels are mounted on a shaft, each wheel being provided with

projecting pins or contact-studs, which are arranged to connect studs or plates during each revolution of the wheels with a number of lines.

1878. T. A. BELL. **4403.**

Improvements in Apparatus for Dividing and Distributing Currents of Electricity. (Provisional.)

Describes the use of a wheel connected electrically with a dynamo machine; this wheel is provided with a contact-maker, and is made to revolve between a number of contact-pieces outside the periphery of the wheel, and which are connected with a number of circuits along which the current is required to pass; as the wheel revolves the contact-maker touches each contact-piece.

1878. H. L. THOMSON. **4462.**

Improvements in or appertaining to the Production of the Electric Light. (Provisional.)

Describes an arrangement for connecting a number of wires by means of a revolving contact-wheel, and thus allowing the current to pass through the respective wires.

1878. C. STEWART. **4466.**

Improvements in Distributing Electricity for the Production of Electric Lights.

Describes an arrangement for diverting the current along a number of wires, by passing a contact-piece over studs connected with the respective wires.

1878. G. R. BODMER. **4476.**

Improvements in Means and Apparatus for Electric Lighting.—(Provisional.)

Describes an arrangement for passing the current from a machine over a number of wires, by means of a contact-spring passing over studs in connection with the respective wires.

1878. E. EDWARDS and A. NORMANDY. **4611.**

Improvements in Methods of and Apparatus for Producing Light, Heat, etc., by Electricity.—(Provisional.)

Uses any ordinary dynamo-machines, and passes the current through the primary wires of induction coils, the secondary circuit of the induction coils being used to produce light.

1878. E. J. C. WELCH. **4635.**

Improvements in Apparatus for Dividing and Distributing Electric Currents, etc.

Describes in connection with each circuit a stud or connection-plate over which passes a contact-piece in electrical connection with the generating machine.

1878. **W. R. LAKE.** 5183.

(From J. B. FULLER.)

Improvements in and relating to Electric Lighting Apparatus.

Describes the use of a number of induction coils, the primary wires of which are connected to the wire from the machine, the secondary wires being connected to the electrodes of lamp.

1879. **A. L. COKE.** 1012.

Improvements in the Mode of Obtaining Electric Lighting.—(Provisional.)

Describes an arrangement for distributing current from a dynamo over a number of wires, by connecting each wire to a stud, opposite which is a moving contact-piece which passes the current from the machine to the lines.

1879. **H. E. NEWTON.** 2769.

(From H. W. COOK.)

Improved Means and Apparatus for Electric Lighting.—(Provisional.)

Describes an arrangement for passing the current along a number of wires, by allowing a moving contact-piece to pass over studs in connection with the respective wires.

1879. **J. HARROP.** 3793.

Improvements in Apparatus, etc., for Subdividing and Producing the Electric Light. (Provisional.)

Describes method of taking a part of the current supplied to a lamp to feed other lamps by means of a contact arrangement attached to the lamp.

1880. **T. A. EDISON.** 33.

Improvements in Apparatus for Developing Electric Currents and Regulating the Action of the same in Circuits that pass to Electric Light or Electro-Magnetic Engines.

Describes a central station using a number of generators, and engines to drive them. Also describes method of dividing a city into districts, and for the regulation of current describes the employment of resistances.

1880. **T. A. EDISON.** 602.

Improvements in the Utilisation of Electricity for Light, Heat, and Power, being an Improved System and Means for the Generation, Regulation, Distribution, etc., of Electricity into Light, Heat, or Power.

Describes and illustrates a plan for central station, with engines, dynamos, etc.

Also illustrates plan of connections for distribution along streets and houses.

1880. **J. M. JUSTICE.** 3637.

(From H. C. SPALDING.)

Improvements in the Art of Lighting Cities by Electricity.

Describes the use of towers having a group consisting of a number of electric lights massed together.

1880. J. B. ROGERS. **3809.**

Improved Means and Apparatus for Dividing and Subdividing the Electric Current for Lighting purposes.

Describes a method of dividing and subdividing the electric current by means of conical, semi-spherical, or bell-shaped apparatus of copper, to the apex of which is a clip or other appliance for the attachment of the primary wire from a dynamo or other electric generator.

1880. P. JENSEN. **3880.**
(From T. A. Edison.)

Improvements in Systems of Conductors for the Distribution of Electricity as a Lighting and Motive-power Agent, and Appliances connected therewith.

Describes various methods and systems of connections for conducting electricity from machines to lamps.

1881. P. M. JUSTICE. **65.**
(From H. C. Spalding.)

Improvements in Electric Lighting.

Uses a number of lamps grouped together in elevated positions.

1881. P. JENSEN. **792.**
(From T. A. Edison.)

Improvements in Electric Lamps and in Circuits for the same.

Describes method of making the proportions of the density or conductivity of the carbon filament, so that, with a standard amount of energy and the standard electro-motive force, each lamp shall give the standard amount of light when a number of the lamps are connected together.

1881. G. A. TABOURIN. **1235.**

Improvements in Apparatus for Electric Lighting.

Describes a system where each arc lamp is provided with a dynamo machine at the place where the lamp is situated. The machine is worked by a small air-engine supplied with compressed air led through pipes from a central station.

1881. A. MASSON. **2013.**

Improvements in Apparatus for Generating and Conveying Electricity.—(Provisional.)

Uses earth for regulating the path of electricity, combined with the application of dualised wires.

1881. E. G. BREWER. **2482.**
(From T. A. Edison.)

Improvements in Magneto- and Dynamo-Electric Machines, etc.

Describes various ways of connecting up dynamo, use of special governor for engine, etc., etc.

1881. **H. E. NEWTON.** 2739.

(From A. Gravier.)

Improvements in the Mode of, and Apparatus for Distributing Electricity, etc.

Describes an arrangement for burning a number of lamps in parallel circuit from one machine. Describes also details of apparatus employed.

1881. **J. IMRAY.** 4128.

(From M. Deprez and J. Carpentier.)

Improvements in the Methods and Apparatus for Distributing and Regulating the Transmission of Electrical Power.

Uses two secondary batteries on a single electrical circuit. While one is giving out its charge the other is being charged. Also describes various arrangements for supplying currents to the dynamo-electric machines. Also describes transmitting a quantity current to a distance by converting it into a current of high tension by means of an induction coil, and this current after being conveyed to a distance is then reconverted into a quantity current by a second induction coil.

1881. **S. VYLE.** 5002.

Improvements applicable to Dynamo-Electric Circuits.—(Provisional.)

Describes connection with various systems of electric lighting; the use of an earth plate connected to the last lamp of a series, thereby dispensing with a return wire.

1881. **C. A. CARUS-WILSON.** 5687.

Improvements in the Means or Apparatus for Controlling and Regulating the Production and Distribution of Electricity.

Describes the use of electro-magnets or solenoids to actuate a lever connected to the governors of an engine driving dynamo machines.

Describes an arrangement consisting of a cup of mercury with a carbon rod suspended in the centre of the cup, driven by engine, whereby owing to the speed of the cup the mercury is driven from the centre towards outside, thus exposing more of the carbon rod in centre of cup, and consequently inserting more resistance and keeping the electro-motive force approximately constant.

Also describes various cut-offs and meters.

1882. **J. PERRY.** 55.

Improvements in Apparatus used in the Distribution of Electrical Energy.

Describes the distribution of electricity over a number of leads and lamps, so that each consumer obtains a supply independent of that supplied to other consumers.

1882. **J. B. ROGERS.** 621.

Improved System or Means of Effecting and Maintaining Currents for Lighting purposes, etc.

Describes the generation of positive and negative currents and their distribution radially from a main station to intermediate station, these again distributing to distant station.

SUBDIVISION VI.

MISCELLANEOUS.

I. REGULATION OF CURRENT BY RESISTANCE OR OTHERWISE.

1878. J. W. T. CADETT. **4022.**

Improved Arrangements for Electric Lighting.—(Provisional.)

The amount of current required for each lamp is regulated by the use of an automatic contact-maker, which is inserted in the circuit in connection with a resistance medium, such as carbon, etc.

1878. W. SCOTT. **4140.**

Improvements in Electrical Apparatus.—(Provisional.)

Resistances are inserted to regulate the strength of current by means of an arm made of two dissimilar metals, which is made by the passage of the current heating same to move over contact-studs in connection with the resistance medium.

1878. E. J. C. WELCH. **4689.**

Improvements in Apparatus for Producing the Electric Light—(Provisional.)

Describes method of regulating the intensity of the currents by inserting wires or rods of platinum, iridium, carbon, etc., in circuit with lamps.

1878. F. J. CHEESBROUGH. **4705.**

(From W. G. Sawyer and A. Mann.)

An Improved System of Distributing, Regulating, Controlling, and Measuring Electric Currents, in the Practical Application of the same to Electric Lighting and other useful purposes.

The current is regulated by means of an automatic apparatus which is made to open and close a valve supplying steam to the engine driving the dynamo machine.

1878. J. H. JOHNSON. **5053.**

(From F. E. De Mersanne and E. Bertin.)

Improvements in Regulating Apparatus used in Lighting by Electricity. (Provisional.)

Describes method of using a platinum wire of certain size, which becomes reddened and forms an indicator showing when a certain number of lamps are in the circuit.

1879. **J. S. SELLON and H. EDMUNDS.** 1692.

An Improved Mode of Regulating Electric Currents.

Describes method of using a wire which is heated and expanded by the electric current, which makes contact with a stud and connects two of the collecting brushes of a dynamo-machine together.

1879. **J. HOPKINSON.** 1959.

Improvements in Electric Lamps.

Describes a form of shunt arrangement attached to arc lamps, so as to allow a number of lamps to be worked in series.

1879. **A. F. BLANDY.** 2060

Improvements in Apparatus for Electric Lighting.

Describes an electro-magnet governor for use with arc lamps. The governor is made of a brass cylinder containing an iron core. Round the cylinder two or more insulated conducting wires are wound parallel to each other. The lamps are connected in respect to the leads and the wires on the coil, so that the current shall pass in one direction through one coil, and in the opposite direction through the other coil. If one lamp is burning and the other be put in circuit, the current would rush through the last lamp and stop the arc in the other lamp, but owing to the form of governor the fact of making the circuit in one branch sets up a momentary induced current in the other, keeping the arc going while the electrodes of the second lamp touch and separate.

1880. **J. IMRAY.** 725.

(From La Société Générale d'Électricité.)

Improved Means and Apparatus for Distributing Currents for Electric Lamps or Candles.

Describes the use of an automatic contact-maker which is used for excluding the current from an electric candle when the candle has been consumed, and which is effected by heating a metal strip.

Also describes an arrangement for closing the circuit of a number of lamps by means of metal pins arranged helically around a shaft, the pins being arranged to make contact in cells containing mercury.

1880. **H. J. HADDAN.** 849.

(From C. F. Brush.)

Improvements in Dynamo-Electric Machines and in Apparatus used therewith.

Describes dynamo machines where the field of force electro-magnets are excited wholly by main or working current, and of arrangements for diverting from a suitable number of convolutions of the field of force helices, to adapt the strength of the magnetic field to the varying requirements of the external or working circuit. This is effected either by shunting some of the convolutions of wire on machine or by an electro-magnetic automatic shunt, the armature

of which is arranged so as to place resistances in circuit for the purpose of shunting a large or small quantity of current from the electro-magnets.

1881. H. J. HADDAN. 1835.
(From C. F. Brush.)

Improvements in Current Governors for Dynamo-Electric Machines.

Describes a form of shunt, the use of which is to prevent a variation in the speed of the revolving armature when the external circuit is variable. It consists of a number of carbon discs placed together, and is acted on by the pressure of a lever to which is attached a core working in a solenoid, the current being shunted through the carbon discs.

1881. J. JAMESON. 2618.

Improvements in Governing Dynamo-Electric Machines and Electro-Dynamic Machines.

Describes a method of using a coil of wire within which is a moveable core of iron which is used in conjunction with other apparatus to regulate the motive-power used for driving, or to regulate the speed of dynamo.

1881. Sir WM. THOMSON. 3032.

Improvements in Regulating Electric Currents and in the Apparatus or Means employed therein.

Describes an automatic appliance to regulate the work of an electric accumulator by increasing or diminishing the number of working cells.

Also describes the use of a small dynamo to utilise the surplus current for regulating the steam power driving the main dynamo-electric machine.

1881. G. WESTINGHOUSE, Jun. 3409.

An Improved Method and Apparatus for Regulating the Production of Electricity.

Describes an automatic electrical arrangement consisting of a solenoid with iron core which is in connection with a lever operating a valve controlling the inlet and exhaust passages to the cylinder, thereby regulating the cylinder of the engine.

1881. R. E. DUNSTON and GUSTAV PFANNKUCHE. 3655.

Improvements in the Division and Regulation of Electric Currents.

Describes an apparatus consisting of two coils of wire, within which is a core of iron which is provided with two racks, one on each side, and by its movement giving motion to two arms which pass over contact-studs and inserts resistances in the circuit.

1881. P. JENSEN. 4034.
(From T. A. Edison.)

Improvements in and connected with Dynamo- or Magneto-Electric Machines and Motors.

Describes an arrangement for regulating the current supplied to a district

from a battery of generators, and which acts as follows:—A resistance is inserted in the circuit of the field electro-magnets, which can be either done by hand or automatically by the current itself.

1881. W. P. THOMPSON. 4168.

(From J. W. LANGLEY.)

Improvements in Governing Apparatus Applicable to Dynamos, etc.

Describes method of placing pieces of magnetic metal in relation to the poles of the field electro-magnets, so that when the machine produces more current than is required by the work to be done, the pieces of magnetic metal are attracted towards the poles, thereby reducing the current generated in the armature.

1881. C. A. C. WILSON. 4825.

Improvements in the means or Apparatus for Regulating Dynamo-Electric Machines, etc.

A small motor driven by the electric current from the main dynamo is used to regulate the speed of engine.

1881. F. WRIGHT and F. A. ORMISTON. 5006.

A New and Improved Method and Apparatus for Regulating the Production of Electricity by Dynamo-Electric Machines.—(Provisional.)

Describes method of placing a greater or less resistance automatically in the circuit of the wire on the field electro-magnets.

1882. W. R. LAKE. 245.

(From A. DE KHOTINSKY.)

Improvements in Apparatus for Regulating Electric Currents.

Describes an arrangement for varying the resistance by means of a column of liquid; also by means of a rheostat similar to a Wheatstone's, the use of which is to place in the circuit of the exciting machine a resistance whereby variations in the intensity of the principal current can be obtained, and establishing by means of a variable resistance a derived current which operates upon the armature of an exciting or generating dynamo before its entrance into the field magnet coils, and so providing means for varying the electro-motive force of the principal current.

II. LIGHTING RAILWAY CARRIAGES BY ELECTRICITY.

1878. DAVIS. 4559.

See Machines—Miscellaneous.

1881. H. E. NEWTON. 4057.

(From Société Universelle d'Électricité Tommasi.)

Improvements in the Production and Employment of Continuous Electric Currents in Railway Carriages, etc.

Driving a dynamo by the motion of the train and using in connection therewith storage batteries.

1881. A. M. CLARK. 4582.

(From J. De Changy.)

Improvements in the Arrangement, etc., of Apparatus for Carriages and Steam Boats, for the Production of Light therein.—(Provisional.)

Describes driving an electric machine by the motion of the train, and using it for charging secondary batteries.

1881. H. J. HADDAN. 4812.

(From W. De Busscher.)

Improvements in Apparatus for Using Electric Lamps on Locomotives and other Vehicles.—(Provisional.)

Describes driving a dynamo from the axle of locomotive. Also arranging a reflector to the electric lamp, which can be operated by the driver.

1881. J. B. ROGERS. 4854.

Improved Means and Apparatus or Appliances connected with the Production, etc., of Electricity, etc.—(Provisional.)

Describes a machine driven from the axle of the engine or carriages, to generate electricity to light up the train.

1881. R. LABOURNE. 5316.

An Improved Arrangement and Combination of Apparatus for Lighting Railway and other Carriages by Electricity.

Describes the use of the shaft of engine or carriage to drive a dynamo-electric machine, and the electricity produced to be used in charging and maintaining the force of a series of Faure's accumulator batteries.

1881. S. PITT. 5600.

(From E. T. Starr.)

Improvements in Electric Lighting Apparatus for Railway Trains and other purposes

Describes a dynamo driven by means of car axle, and using in connection therewith a storage battery and appliances for lighting the train.

1882. W. H. PREECE and J. JAMES. 129.

An Improved Method and Apparatus for Electrically Lighting Railway Trains.

Describes a means of compressing air by means of axles of carriages, and using it to drive dynamo machines.

1882. S. PITT. 819.

(From E. T. STARR.)

Improvements in Electric Lighting Apparatus for Railway Trains and other Moving Vehicles or Vessels.

Describes details of fittings only.

1882. WILLIAMS. 856.

See Storage.

III. VARIOUS.

1878. A. AUCKLAND COCHRANE. 4313.

Improvements in Obtaining Electricity and in the Application thereof to the Electric Light and to other purposes.—(Provisional.)

Utilising the electricity developed by the heating and vaporisation of liquids or fluids, for giving the electric light.

1878. A. P. CHAMBERLAIN. 5078.

(From A. H. HEARINGTON.)

Improvements in Lighting or Illuminating, and in Apparatus to be used therefor. (Provisional.)

Describes producing light by combining gas and electricity, the electricity being generated by means of galvanic elements.

1880. J. E. H. GORDON. 1826.

Improvements in Apparatus for Producing Electric Light.

Describes a lamp where light is given from refractory metal heated by the discharge of the secondary circuit of an induction coil excited by a dynamo machine.

1881. A. SHIPPEY. 879

Improvements in Electric Light Signalling, etc.

Describes attaching an electric lamp to a balloon, one wire being attached to a float for a return, the other wire being led from machine to the balloon.

1881. W. E. HUBBLE. 3455.

(From A. F. W. PARTZ.)

Improvements in Electric Lighting and in Apparatus employed therein. (Provisional.)

Describes the placing of a lamp underground, and which throws light upwards through a tube on to a reflector.

1881. E. B. BURR and W. F. SCOTT. **5604.**

Improvements in Galvanic Batteries for Electric Lighting, and for other purposes.

Describes a form of box divided into cells containing zinc and carbon packed with asbestos or other like material saturated with acid solution constructed and arranged in combination with an incandescent lamp. This is said to give incandescence for several hours.

The PRESIDENT: I am sure I am only expressing the sense of the meeting in thanking Col. Bolton most heartily for his labour in this matter, and I will ask the meeting to show its approval by responding most heartily to this expression.

(*The proceedings of the meeting will be continued in the next issue of the Journal.*)

THE SOCIETY OF Telegraph Engineers and of Electricians.

COUNCIL.—1883.

President.
WILLOUGHBY SMITH.

Past-Presidents.
CHARLES WILLIAM SIEMENS, D.C.L., F.R.S.—1872 AND 1878.
FRANK IVES SCUDAMORE, C.B.—1873.
SIR WILLIAM THOMSON, LL.D., F.R.S.—1874.
LATIMER CLARK, C.E.—1875.
C. V. WALKER, F.R.S.—1876.
PROFESSOR ABEL, C.B., F.R.S.—1877.
LIEUT.-COL. J. U. BATEMAN-CHAMPAIN, R.E.—1879.
W. H. PREECE, F.R.S.—1880.
PROFESSOR G. C. FOSTER, F.R.S.—1881.
LIEUT.-COLONEL C. E. WEBBER, R.E., C.B.—1882.

Vice-Presidents.
PROFESSOR W. G. ADAMS, F.R.S.
C. E. SPAGNOLETTI, M. Inst. C.E.
PROFESSOR D. E. HUGHES, F.R.S.
SIR CHARLES BRIGHT, M. Inst. C.E.

Members.
W. S. ANDREWS.
WILLIAM T. ANSELL.
PROF. W. E. AYRTON, F.R.S.
E. B. BRIGHT.
T. R. CRAMPTON, M. Inst. C.E.
H. G. ERICHSEN.
H. C. FORDE, M. Inst. C.E.
Dr. J. H. HOPKINSON, M.A., F.R.S.
J. FLETCHER MOULTON, F.R.S.
ALEXANDER SIEMENS.
AUGUSTUS STROH.
C. F. VARLEY, F.R.S.

Associates.
Lieut. ARTHUR H. BAGNOLD, R.E.
SHELFORD BIDWELL, M.A., LL.B.
J. C. LAMB.

OFFICERS.

Auditors.
J. WAGSTAFF BLUNDELL, 12, Delahay Street, Westminster, S.W.
FREDERICK C. DANVERS (India Office).

Hon. Treasurer.—EDWARD GRAVES.

Hon. Secretary.—LIEUT.-COL. FRANK BOLTON.

Hon. Solicitors.
Messrs. WILSON, BRISTOWS & CARPMAEL, 1, Copthall Buildings, E.C.

Chairman of the Editing Committee.—PROF. W. E. AYRTON, F.R.S.

Librarian.—ALFRED J. FROST.

Secretary.—F. H. WEBB.

Bankers.
Messrs. COCKS, BIDDULPH & Co., 43, Charing Cross, S.W.

Library and Offices of the Society.
4, The Sanctuary, Westminster, S.W.

LOCAL HONORARY SECRETARIES AND TREASURERS.

JAMES ALLEN, Telegraph Superintendent, Great Southern Railway, Buenos Ayres	ARGENTINE & ORIENTAL DEL URUGUAY REPUBLICS.
Don JOSÉ APARICIO, Representative of the Direct Spanish Telegraph Company, Calle de Fernando VI., Numº 1, Madrid	SPAIN.
JOHN AYLMER, Civil Engineer, 4, Rue de Naples, Paris	FRANCE.
J. M. COLLETTE, Engineer of the Netherlands Telegraphs, The Hague	The NETHERLANDS.
E. C. CRACKNELL, Superintendent of Telegraphs, Sydney	NEW SOUTH WALES.
JAMES DAKERS, Manager, Montreal Telegraph Company, Montreal	CANADA.
Le Commandeur E. D'AMICO, Director-General of the Italian Telegraphs, Rome	ITALY.
FRÉDERIC DELARGE, Engineer of the Belgian Telegraphs, Brussels	BELGIUM.
N. ISPOLATOFF, Director of Telegraphs in St. Petersburg	RUSSIA.
CHARLES LEMON, Ph.D., Superintendent of the New Zealand Telegraphs, Wellington	NEW ZEALAND.
C. L. MADSEN, 49, Norre Sogade, Copenhagen	DENMARK.
SAMUEL W. MCGOWAN, Chief Inspector of Telegraphs and Postal Service, Melbourne	VICTORIA.
C. NIELSEN, Director-General of the Norwegian Telegraphs, Christiania	NORWAY.
J. R. PREECE, Indo-European Government Telegraphs, Shiraz	PERSIA.
E. ROSENBUSCH, A.M. Inst. C.E., Engineer, Mediterranean Extension Telegraph Company, Valetta, Malta	MALTA AND THE MEDITERRANEAN.
Dr. WERNER SIEMENS, 94, Markgrafen, Strasse, Berlin	GERMANY.
J. SIVEWRIGHT, M.A., C.M.G. General Manager of Telegraphs, Cape Town, Cape of Good Hope	THE CAPE AND SOUTH AFRICA.
F. G. TEALE (Acting Local Hon. Sec. and Treasr.), Indian Government Telegraphs, Calcutta	INDIA.
CHARLES TODD, C.M.G., Director-General, South Australian Telegraphs, Adelaide	SOUTH AUSTRALIA.
G. G. WARD, Gen. Superintendent of the Direct United States Cable Company, New York	NORTH AMERICA.
WILLIAM WARREN, Superintendent in Tasmania of the Eastern Extension Australasia and China Telegraph Company, George Town	TASMANIA.

JOURNAL

OF THE

SOCIETY OF

Telegraph Engineers and of Electricians.

VOL. XI. 1882. No. 45.

The Proceedings (continued from page 516) of the One Hundred and Fourteenth Ordinary General Meeting of the Society, held on Thursday evening, November 9th, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Colonel C. E. WEBBER, R.E., C.B., President, in the Chair.

The following paper was then delivered :—

THE MUNICH ELECTRICAL EXHIBITION, 1882.

By W. H. PREECE, F.R.S.

Mr. President,—To occupy your attention for one hour or more in describing the mere contents of an Electrical Exhibition is rather an arduous task, unsupplemented as I am with any apparatus or diagrams, and but one or two photographs to which I shall call your attention.

First of all, I think I ought to say one or two words as to the reasons which took me to Munich. You all know that there has been an Exhibition at Munich, and that this Exhibition was called an "International Exhibition." Invitations were sent by the governmental authorities in Bavaria to the different governments and different people connected with electrical enterprises; but, by some strange misfortune, the invitations from Munich that should have reached those who alone are interested in electrical enter-

prise in England, failed to get there. Up to the present moment the Post Office has received no invitation, and the Society of Telegraph Engineers and of Electricians, that took such a very active part in assisting the French authorities in carrying out their exhibition last year, only received an invitation to go to Munich on the 13th September, whereas the Exhibition itself commenced upon the 16th of that month. The result has been that England was not properly represented at Munich.

This Exhibition was called an "International Exhibition:" there is no doubt it was if the word "inter" were left out. It was a national exhibition. Everything was in German—the catalogue was in German, the notices were in German, and, with very few exceptions, the exhibits were all German; more than that, they were *South* German, for North Germany, that is so intimately associated with the progress of electrical progress, was conspicuous by its absence. There was nothing from the great house of Siemens and Halske, nor from that of Felten and Guilleaume, and, with the few exceptions referred to, nothing was exhibited but that which came from the workshops and administrations of South Germany. But, nevertheless, the Exhibition was an extremely interesting one. It was small. The one in Paris last year had 1,700 exhibitors; Munich had 170, or exactly one-tenth; the Crystal Palace had only 300; but, nevertheless, the small number of exhibits at Munich were quite on an equality with the more numerous things which were at Paris and at the Crystal Palace.

Munich, where this Exhibition was recently held, is very much distinguished in the annals of electrical history by its association with Steinheil's discoveries. Steinheil claims, with Morse in America, and Cooke and Wheatstone in England, to have been the first to introduce practical telegraphy, and in 1837 he certainly did produce a practical telegraph, and he is unquestionably the originator of the system of using the earth as the return. Hence the inhabitants of Munich claim some credit, and with justice, for the introduction of telegraphy into this world.

The Munich Electrical Exhibition was held in a glass palace; a very beautiful copy on a small scale of our own Crystal Palace.

The design is nearly the same, excepting that there is but one transept.

The object of the Exhibition was, not only to bring before the German world the progress of telegraphy and electricity, but also to introduce a series of experiments that should establish on a more scientific basis than hitherto had been the case, the capacity and the merits of different apparatus. Another great object was to display in the very best artistic manner the power of electricity to illuminate space, and the artistic efforts made by our friends in Munich were certainly crowned with very great success; for we have seen nothing in England, nor did we see anything in Paris, which could surpass the artistic grace and elegance evinced in the way in which rooms and places were illuminated. The building was entered by a main entrance, corresponding to the entrance to the Crystal Palace from the garden, and on entering there appeared an exceedingly pretty garden, laid out with great care, well planted with bedding-out plants, and arranged with great taste. In the centre of this garden was a handsome fountain playing to a very great height, and at night a pretty effect was shown by means of the electric light being thrown on to the rising column of water through coloured lenses.

In the building, immediately on the right after entering, was a representation of the past and present. The past was a copy of an old hut wherein was found furniture of the oldest and darkest oak, a plain and simple table and stool, a spinning-wheel, a crucifix, and an old iron clock, and the interior was lit up by not quite the ancient dip, but the very old and greasy oil lamp. Immediately beyond this well-arranged hut was a library of the modern day, fitted up with the most expensive, artistic, and beautifully carved furniture, everything that luxury could command or riches produce, which splendid lofty apartment was lit up by the latest luminant, the incandescent lamp; and the contrast between the two was certainly the most striking thing, not only in that Exhibition, but, I think, that I have ever seen elsewhere. The artistic displays in Munich were carried out by a local society called by a name corresponding very much to our Society of Arts; and there there were several rooms, drawing-

rooms, dining-rooms, and others, fitted up with expensive and elegant furniture, and lit up by various systems of incandescent lighting. But apart from the artistic display, which was one of the chief merits and peculiarities of the Exhibition, there was also organised a system of technical measurements that will certainly mark, when they are complete, an epoch in the history of electrical works. I will dwell a little more presently on those technical measurements which will be the remarkable feature of the Munich Exhibition, and I hope—I had hoped to-night—at some future day to have figures to bring before you; but the labours are rather excessive, and, although the Committee have worked very hard, they have not yet succeeded in completing all the figures, and the results, therefore, are not before us.

Another peculiarity of the Exhibition was that there are to be none of those absurd gold, silver, and bronze medals that provoke annoyance and vexation of spirit, create envy, hatred, malice, and all that sort of thing, but instead there will be simple certificates. Every exhibitor is to have a certificate that shall give the results of the measurements made on the different apparatus by the members of the jury, or by the particular jury that takes upon itself the particular section of measurements. When we have 10 dynamo machines in one particular class, and we have from a first-class jury a record of the performance of these machines, it is infinitely better, when put in proper electrical language, than any gold medal or any other form of selective award, either on paper or of metal. These awards, when given, will also be accompanied by reports which will be very ably drawn up, for the men engaged in this work are very able men, and they will have this one great benefit, that they will check a great deal of that amateurish nonsense that we read in the papers, or that absurd romancing that unfortunately disfigures the Press. We shall have absolute facts put in scientific language and vouched for by men whose scientific attainments are unimpeachable; in fact, they will put an end to a great deal of those evils of ignorance which are manifest at the present day. It is really this ignorance which has succeeded in forcing upon the market those unfortunate schemes which have

filched millions of money from the British public, the early return of which may be at present problematical.

The Munich Exhibition was well filled every night. In the day it was quiet, but there was, as is the case in most exhibitions, a place for refreshments. The place for refreshment at Munich surpassed anything that we had in Paris. Paris was very good, but at Munich there was an elegant garden, with a band playing, and we had *beer*. Now, if there is one thing that I have not learned at the Munich Exhibition, it is this: I have not learned to measure the beerostatic capacity of the average Bavarian, and it cannot be expressed in absolute measurement; in fact, my own capacity increased in Munich in the most wonderful way, for I confess that under the influence of electricity, kindness, and music I succeeded in consuming in the four days I was at Munich more beer than I consumed in the previous four years of my existence.

There were 15 classes and 12 juries. I will not go into detail of them at once, but will follow as closely as I can the class and the order in which the exhibits were arranged about the building. But I have not said all I should like to say about the building. I told you that in the centre there was a beautiful fountain. This fountain played a great trick upon me. The railway passes close by the building, and on my arrival at Munich the building appeared to me to be on fire, and I thought to myself, "Here's a pretty go: the first week of this electrical exhibition, and it is on fire. What will the gas people say?" The flames were ascending, and the water playing on them. Well, I had travelled 23 hours, but the 23 hours' travel and the want of a dinner did not deter me from rushing to the Exhibition to see it on fire, and when I got there I found it was nothing but this fountain, which had been lit up by the red lens of the electric light, and the reflection of the fountain itself in a glow of red light on the glass of the building looked exactly as though the fire brigade were pumping water on the flames.

In the nave there was a copy of an old Norman church, made of lath and plaster and painted canvas, which was a most perfect representation. It was fitted up inside with all the appurtenances

of a church, and there was a kneeling lay figure dressed in all the vestments of some very high office,—some said a cardinal, but I think not; it was, however, a priest of a very high degree,—and playing on this lay figure, the Society of Telegraph Engineers will be glad to know, was a lamp of our old and good friend Mr. Crompton. This little church was lit up by the Crompton arc light, and the effect was very impressive and very beautiful.

On the other side of the nave there was a theatre capable of holding 200 or 300 people, fitted with a stage, footlights, set scenes, and scenery, and every evening there were representations, *tableaux vivants*, and ballet dances, lit by the electric light. The footlights were incandescent lamps. Festoons of incandescent lamps hung around the theatre, while from the centre an arc light shed its rays over the whole house.

In this nave there was also a picture gallery, and this was the greatest failure in the whole place, at any rate during the time I was there; for, if it were possible to show how not to light a picture gallery by electricity, they succeeded admirably at Munich.

Externally, the electric light was shown in various ways, by lighting streets. The Grand Platz, where the picture gallery and the triumphal arch commemorate the independence of Greece, was lit up by four arc lights, and I am bound to say that the effects of the arc lights externally, and of the incandescent lights internally, fully confirmed what I have more than once stated, that the proper function of the arc lighting is for external purposes, and of the incandescent lamp to light interiors.

There was a good display of electric machines and accumulators, and of cables. I must not go through all the things that struck me, I must be a little brief in my remarks, so that I cannot dwell upon all that I saw, but one of the favourite instruments there was the induction machine (which we know here as Voss' or Holtz'), under different names, and there were many. There were also many hand dynamo machines. There is one want cropping up constantly, and that is a handy and portable dynamo machine that can be worked by the hand, that can be carried about to illustrate experiments, which can be used in the laboratory or lecture table, which does not cost much, and which shall be

always ready to give a current of an ampère or more, and light up two or three incandescent lamps. At Munich there were heaps of such machines, costing from about £15 to £20 each, and there were men simply turning them round, and assistants showing the decomposition of water, the magnetic attraction of large electro-magnets, lighting up incandescent lamps, and other things of that kind, to amuse the population. When I was in Paris in the early part of the year I saw a machine of this character, and I exhibited it at the British Association, and Professor Adams also has done the same with it at Falmouth, and that machine of De Meritens is just the very sort of thing that is wanted. I hope some night to bring it before the Society, that the members may see for themselves how, by exercising a little muscular power, we can produce currents of electricity, to show all the great effects that are seen in electric lighting and in the transmission of power.

Accumulators.—Planté showed his accumulators; the principal part of his exhibit from Paris was there. There was a new accumulator, but although it was new I do not think it indicates any step in advance. It was the invention of Herr Shulze, of Strasburg. The novelty is that Herr Shulze takes his lead plates and coats them with a thin superficial layer of plumbic sulphide (Pb.S). The lead plates, very finely grooved, are heated in sulphur, in what form I do not know, but they come out coated with a superficial layer of what we used to know as the black sulphuret of lead; this is put into a bath of sulphuric acid, and the result is that there is sulphide of lead opposed to sulphide of lead, through which the current goes with the result that on the one plate the hydrogen and the water combine with the sulphur, forming that sweet and delightful perfume called sulphuretted hydrogen; indeed, the effect of the current on this plate in producing sulphuretted hydrogen was only too evident in the neighbourhood of this secondary battery, for the smell of rotten eggs is sweet to the odour of Herr Shulze's secondary battery. When the operation is complete, and when everybody is driven away, then it is said that the battery is ready for action.

Each cell when complete weighs 23 lbs., and it takes a current of 4 ampères for 60 hours to form it. When charged, the internal

resistance is equal to ·005 ohms, while the electro-motive force is 2·1 per cell. I take the chemical operation performed to be as follows:—

$$\begin{array}{c|c|c} 2\,Pb.S & \begin{array}{c} H_2SO_4 \\ 2\,H_2O \end{array} & Pb.S \\ & & \\ \begin{array}{c} 2\,H_2S \\ Pb. \end{array} & H_2SO_4 & \begin{array}{c} S \\ Pb.O_2 \end{array} \end{array}$$

indicating thus that sulphur is precipitated while sulphuretted hydrogen is given off. The inventor says that he puts into each cell 40 watts, while he gets out 20 watts: the efficiency is therefore not very great.

Cables.—One would have thought that in the home of subterranean cables there would have been something shown in the way of conductors or cables or wire, but there was absolutely nothing. I have already said that the Berlin house of Siemens and the Cologne house of Felten and Guilleaume were conspicuous by their absence. The Swiss firm of Berthoud and Borel exhibited their copper wires surrounded with paraffin in lead tubes, and their system was used all over the building for the conveyance of currents, but I know of nothing particularly novel or striking in this wire.

There was a very good display of phosphor bronze wire. Phosphor bronze has one supposed merit, and that is that it is the most durable wire in the air that we know of, also that it is very light and very strong; but hitherto it has had the defect of very high resistance. But Montefiore-Levi, of Brussels, exhibited some phosphor bronze wire at Munich, of 14½ gauge, which had a breaking strain equal to steel and a resistance equal to copper; in fact, some specimens tested showed that it was equal to 95 per cent. of pure copper. It is receiving a small trial in England. We have some at the Post Office, and it remains to be seen how far the alteration in its conductivity has affected its durability. It may be that it has gone through some process that may lead to a more rapid action on the part of the air, but this is one of those points that requires to be investigated.

Historical Apparatus.—In this class there was Sömmering's

original telegraph of 1809, Steinheil's apparatus of 1837, and Reis' original telephone of 1861, and the latter certainly succeeded in attracting a great deal of attention from the audiences there, no doubt from its having played such a conspicuous part in the history of telephones during the past three or four years.

Electric Lighting.—As regards engines, I cannot say much. There was only one that deserved the name of an engine, and that was by a firm new to the electric light world, viz., Ruston and Proctor, of Lincoln.

Shakespeare says that a "rose by any other name would smell as sweet," but I doubt very much whether an inventor would consider that an invention of his would smell as sweet when he had seen it under another man's name. There was a dynamo machine exhibited by a firm, who made a very good display, but when it was examined we found that it was nothing but a Siemens dynamo pure and simple. Again, there were machines shown under the name of Seligman, which under examination proved to be our old familiar friends the Brush, made probably in London and sent over to Munich. Yet again, a machine was exhibited under the name of Neumayer, which was an Edison pure and simple, the only variation being that the field magnets were wound thicker at the pole than they were higher up. But the most glaring case of the kind was in the class of batteries, where a grand display was made by a firm, Lessing, of Nuremberg, of a battery which was nothing more nor less than the Leclanché. Such things are perhaps done in England. I have seen the name of a manufacturer taken off and the name of another manufacturer put on; but I think that when exhibitions of this kind are carried out, some little care should be exercised to see that the true inventors received their full reward in some way or other.

Dynamo Machines.—The greatest exhibitor was Schuckert, of Nuremberg, who showed some very admirable machines, which I am sure will come out favourably in the final reports of the jury. Munich rests on the river Iser; and when I stood on the bridge at Munich, and looked at the water flowing past, my school-days were irresistibly brought back, by being reminded of "Iser, rolling

rapidly." You all, perhaps, remember Campbell's poem of the "Battle of Hohenlinden," where he says:

> "On Linden, when the sun was low,
> All bloodless lay the untrodden snow
> And dark as winter was the flow
> Of Iser, rolling rapidly."

And there Munich rests on the Iser, which goes rolling and tumbling along, expending wasted energy to a terrific extent; and one could not help fancying that if our old friend Crompton or Alexander Siemens were there, they would soon utilise "Iser, rolling rapidly," and light up the town of Munich. Schuckert did this to some extent. He had one of his machine 5 kilomètres off at the Falls of Hirschau, where it was worked by a turbine moving at 1,650 revolutions, and giving out 12 horse-power. That 12 horse-power produced a current of 8 ampères through about 120 ohms resistance, and lit up 11 arc lamps, seven of them being in the Palace and four in the Grand Platz. Such a performance was very creditable to Herr Schuckert and "Iser, rolling rapidly."

The transmission of power was one of the great features of the Exhibition. Marcel Deprez from Paris was there, and he had an apparatus at a place called Miesbach, 34 miles from Munich, where a gas-engine was fixed. Two wires connected the two towns together,—they were 4·5 mm., equal to English No. 7 gauge, resistance 950 ohms,—and by using two Gramme machines of the A pattern, wound to high resistance, he succeeded in reproducing at the Glass Palatz at Munich ½ horse-power. That was a very good result, and our French friends have become tremendously enthusiastic over the result: ½ horse-power reproduced at a distance of 34 miles is a very good performance, but they have not told us yet how much power was put into the machine at Miesbach to produce the result, nor have we yet heard how much power was wasted *en route.* I am afraid many of those electrical gentlemen who are experimenting so much with electrical currents have not yet had sufficient experience of telegraph lines in damp countries to enable them to predicate the effect of loss of current due to leakage, to contact, and to bad insulation. I got Mr. H. R. Kempe, whose mathematical abilities are well known, to calculate

for me what would be the effect of leakage on a wire 100 miles long when the insulation runs down from what we call perfection to the ordinary limit that occurs in very wet weather. While the weather is very good, the loss due to leakage is only about 3 or 4 per cent.; when the leakage becomes equal to that which a wire in England actually assumes in very wet weather, then the loss due to leakage becomes nearly 60 per cent. Well, if between Miesbach and Munich a loss of current occurred, then I venture to predict that the ½ horse-power received at the end of the 34 miles must be materially diminished unless other resources be adopted to increase the electro-motive force at the transmitting end. However, I am sorry to say that I was not infused with any particular enthusiasm from the experiment I saw, although it certainly marks a very great step in advance, and is certainly a very wonderful thing to know, that you can from Bristol convey a portion of the power developed by the rise and fall of the tide in the Avon, and use it in Gloucester to produce half a horse-power, for that is really tantamount to what was done at Munich.

Amongst electric lighting there was nothing very new. I think, though I do not know whether the Committees will agree with me, that the palm in electric arc lamps was carried off by Mr. Crompton. His lamp was simple, for he has modified and simplified it very much: it burned with great steadiness. I ought to have said that Mr. Crompton was the only English exhibitor; and I think he has got such energy that, if the Chinese were to get up an exhibition, we should find him exhibiting his arc lamp in Pekin.

There was a rather novel portable arc lamp exhibited, which was worked by a Schuckert dynamo machine, and was all arranged on a truck suitable for running on railways. Attached to the truck was a square lazy-tongs pole, which when drawn out formed a handy lamp-post, and the whole arrangement could be carried about in case of emergency, and formed a neat, portable combination.

Amongst incandescent lamps were our usual friends that we know so well, the Edison and Swan; and there were one or two others that were very like Edison and Swan, and were either or both under different names. For instance, I took a note of a lamp,

exhibited by Greiner and Friederichs, that bore such a close resemblance to the Swan that I should think it was made in England. But there was one lamp which possessed a great improvement on the Swan, by Müller. The whole arrangement of this lamp was the same as the Swan, excepting that the carbon was twisted, instead of being in the usual form of the Swan.

But there was a lamp that was new. It was the invention of a Signor Cruto, an Italian. This gentleman for 12 years has devoted his time to the discovering of a mode of constructing artificial diamonds: he has succeeded in producing an incandescent lamp. From diamonds to lamp may be rather a curious step; but the operation of the lamp is to take a loop of platinum wire, and while that wire is raised to incandescence in a globe containing carburetted hydrogen by dissociation, carbon is deposited on the platinum wire, and, after a proper thickness has been obtained, this wire is fused away or deflagrated or vaporised away in some manner. Anyhow, there remains a loop which is composed of a tube of carbon, and the particular merit of the tube is said to be this—I only say "said to be," because I accept the figures; I did not have a chance of measuring, as the lamps were under a glass case, and there were too few of them to dare to burst one up with a current, and therefore I was obliged to accept the figures—that the carbon tube gave a light of 12 candles with a current of half an ampère. If that be true, there has certainly been a very great step in advance. I do not know that it is new, I have not heard of it before; but I am one of those who believe that there is nothing new under the sun, and should not be in the least surprised to see half a dozen gentlemen jump up and say that it is not true, that they invented it 20 years ago; but it struck me as new, and I thought I had better bring it before you.

In telegraphs I did not see much that was new; in fact, I am happy to think that they have not much in Germany or on the Continent anywhere to teach us in England as regards telegraphy. I say it, who ought not to say it, perhaps, but I think that we do possess in England the finest working telegraph in this world; anyhow, we transact an amonnt of business that far exceeds even that transacted in America, and we have the great satisfaction of

knowing that even the Americans themselves have come to us for apparatus to carry off their greatly increasing business. In Munich I simply saw the old slow and steady Morse. There were three offices fitted up very perfectly, neatly, and nicely, showing exactly how telegraphs were worked. The different forms of apparatus used on the Bavarian railways were exhibited, one being an arrangement by which it was possible to call up any particular station out of a long series, an admirable call system that was also exhibited in Paris by Wetzer, where it was possible to call up in the night time any particular station. It would no doubt be a considerable advantage on many of our railways in being able at any hour of the night to ring a bell at the head of a telegraph clerk or stationmaster when in bed; at present when a station is closed at night it remains closed until the next morning.

With regard to telephones there was not much to learn, excepting that one saw how easy it was to make very bad telephones.

There was a room set apart for the transmission of music. There was another room set apart by a M. Weigle, who showed a telephone having a disc about as big as three times the size of the moon as it is supposed to appear from the earth, or something like 3 feet in diameter, or perhaps more like the disc of tissue paper through which the light and active horsewoman bounds in a circus. M. Weigle's idea was that with such a disc he would enable all the persons in a large room (such as this) to hear music which was transmitted from Ober Ammergau, a distance of 60 miles. I need not say that M. Weigle was miserably disappointed; nothing but a big boom, like Big Ben or Great Paul, was all that I heard from that gigantic telephone disc. But M. Weigle had one pretty little thing there, which was an application of Edison's apparatus, by which he succeeded in boring a hole through a piece of wood by speaking. In this apparatus the vibration of the disc rotated wheelwork that caused a coloured disc to vibrate, and one could see, by putting different coloured discs on the vibrating apparatus, all the effects of the mixture of colours, indicating the speed with which the apparatus moved, and, in point of fact, making an extremely pretty toy.

There was one very curious effect I learned there, and, if it be true, a most serious effect. I do not think it can be true, or we should have heard something of it. It is that with a Bell telephone the influence of the magnet upon the ear or ears is to produce a species of insensibility, and that when two receivers or two magnets are held to the ears for some time a temporary deafness occurs; and I was told that even if one's finger were put between the poles of a magnet and held there long enough, the finger would practically get dead. I have not had time or patience enough to hold my finger there long enough, but perhaps some members of the Society may, for the benefit of science in general, and ourselves in particular, between now and next meeting, hold their fingers between the poles of a magnet until they lose sensibility in that finger.

Fire alarums were exhibited, as also automatic signals, and thermometers that registered temperature and raised alarms when they came to a certain point. Lightning protectors were in abundance ; and, if there is one thing that does distinguish Germany more than any other, it is the care with which they protect all their prominent and large buildings from lightning by means of lightning rods. In England, although we have striven for years and years to bring the subject before the public; although we have had a Lightning Rod Conference sitting for two years; although we have had papers before this Society; and although the different organs of the Press have at different times enlarged on the necessity of the employment of lightning protectors, the British public remains callous, and can not be persuaded to put up a lightning protector until his house has been struck and destroyed. In Germany lightning protectors are found everywhere. In Stuttgart it is one of the striking features of the town; in Munich they are everywhere; and at the Exhibition itself there was a very excellent and admirable display by various exhibitors, showing how thoroughly they have carried out the principles, and how much their conclusions were in accord with the conclusions arrived at by the Lightning Rod Conference, which issued its report last year.

Railway signalling was illustrated on a very large scale. The

Chemin de Fer du Nord had the same exhibit as at Paris, and it created a good deal of interest.

Clocks, bells, current-meters, little apparatus which registered the flow of water in the beds of rivers, and recorded the rate at which currents and tides ran—some we have seen in England; but there were a good many others, but all were exquisitely and beautifully carrried out.

There was nothing new in batteries.

Electrotyping was shown. It was quite possible to have your keys nickel-plated. I was rather taken in in this portion of the establishment. I am sorry I did not bring the article with me, but there was a man doing a capital business by the sale of little things which he reproduced, such as medals. Having laid out a little money in those things that were practically useless, I thought I would buy something that was useful. So among the things that were laid out there was a beautiful match-box which I bought, and on bringing it back to London I was very sorry to find that the match-box was identical with those shown in our shops at 1s., patented and manufactured in America.

Medical Application of Electricity.—Apparatus of this class was shown on a very large scale. Our friend Dr. Stone would have been delighted to have seen the little instruments exhibited there for surgical and medical purposes. There was Dr. Von Ziemssen, who has devoted a good deal of attention to this, and who exhibited a series of photographs which really are the only things that I succeeded in getting or obtaining the loan of from Munich; and, through the kindness of Dr. Von Ziemssen, I am able to show you to-night a series of those photographs which represent the involuntary contortions of the facial nerves when under the influence of electricity [pointing to the series]. The same old gentleman, who in his quiet and placid moments is very good-looking, is the subject in each photograph. Dr. Von Ziemssen applied the poles of his electro-medical apparatus to various nerves (I am not familiar with the names), and from the photographs you will easily distinguish the expressions of joy, pain, surprise, doubt, disgust, and so on, brought about by the application of the electrodes to the respective muscles.

It will be in the testing arrangements and the results of the examination of the instruments that this Exhibition will be principally notorious in future years. It certainly was the best arranged, the most complete and perfect system that I have yet seen anywhere, to produce electrical results. There was plenty of space, plenty of apparatus, plenty of assistants, and every assistant a professor. There was a rheostat of natural resistance almost of a character that I do not think has been constructed before. One of the galleries was set apart for this purpose: a long gallery some 200 or 300 feet in length had an array of poles upon it, the poles were fitted with insulators, and along the gallery were extended copper wire of 7 mm. diameter, and a series of iron wire 3 mm. diameter and of 4·5 mm. diameter, allowing of a varying resistance of from ·1 ohm up to 150 ohms in wire exposed to the air, where cooling took place rapidly, and where it was possible all along to take temperature records from thermometers suspended at intervals, which gave the exact state of the atmosphere at the time when the experiments were made. Various galvanometers were brought into requisition: the reflecting galvanometer of Wiedemann, the electric dynamometer of Siemens, the galvanometer of Deprez, all graduated by comparison on an elecrolytic process. There is nothing easier than to verify the deflection, the records, of any galvanometer, or to verify the readings of any electro-dynamometer by this process. A current of electricity decomposes a given quantity of metal in a given time. A current of an ampère in one hour will deposit 1·19 grammes of copper, or 1·22 grammes of zinc. The best liquid by far to experiment upon is sulphate of zinc, because there all the effects of polarisation are got rid of, and disturbance from variation of resistance. By simply measuring the amount of zinc deposited in a given time by the electro-chemical equivalent, by dividing the amount deposited in a given time by this figure, is obtained a figure representing the current in ampères indicated by the galvanometer through which the current flows, and at Munich this plan is followed out. The indications and deflections of the various galvanometers are frequently verified by comparison with a voltameter, where the decomposition is very carefully recorded. Then there is the

torsion galvanometer of Siemens, for measuring electro-motive force, also the quadrant electrometer to verify the observations of the other instruments,—and in fact every observation was checked by two or three men, and checked by two or three instruments,—so that when we do get the results from Munich, I for one shall have absolute confidence in the accuracy of those results, because I know the great care taken to obtain them. There was no attempt made at introducing novelties, and no personal idiosyncrasies. Most electricians are very fond of adopting or forcing down the throats of everybody else their own notions, but at Munich there was a body of men who took possession of the simplest possible way of arriving at results, and of stating them in very elementary and simple language. Books have been printed, one by Dr. Kittler, another by Dr. Schröter, and a third by Drs. Voit and Krüss, which I have not got, relating to photometric measurements, and we shall have the results. Dr. Beetz, who was the head of the Exhibition, promised that all the papers, records, books, and everything published should be sent to the Society of Telegraph Engineers and of Electricians, for deposit in their library.

Everything exhibited was examined for its current strength in ampères, for its electro-motive force in volts, and for its resistance, unfortunately, in Siemens units. But the accuracy with which the ratio between the Siemens unit and the British Association unit and the true ohm is now known, is such that, whether the result be obtained in the one unit or the other, it is a very easy thing to calculate it to its proper figure, only it certainly would conduce very much to more universal acquaintance with the results of the Committee if they were all put in the same language, and we had ampères, volts, and ohms, as well as some of the other later units that have been proposed.

The resistance of the lamps will be shown, and has been determined by substitution, and all the measurements, owing to the grand army of assistants that Dr. Beetz has for observation, were to be made simultaneously; so that while one jury was observing the power thrown into a dynamo machine, another recording the velocity and the heat of the dynamo machine, another recording the current flowing through the circuit, and a fourth taking

measurements of the electro-motive force and of the resistance and of the current, all were taken simultaneously and recorded simultaneously, and the results will conduce very much to their accuracy, which is not to a great extent the case with observations that have been made at other places.

There will thus be the measurements of the incandescent lamps, the arc lamps, the electrical work absorbed in the lamps by each lamp, the candle-power, and the candle-power per horse-power; and it is necessary to know that the horse-power in Germany is not the horse-power in England. They adopt the French horse-power, which differs from the English, 736 : 746. The French *cheval-vapeur* and the English horse-power are represented by those two numbers. All the German records will be given in the French 736, instead of the English 746.

For a photometer standard they have taken our well-known English candle. Now, if there has been a battle on the Continent over various units, I think the greatest battle has taken place over this unit of light. The French are very sweet on their Carcel *bec;* we love our old candle. Fortunately, in Germany they have no dear friend either in the form of a candle or in the form of an oil lamp, so they have taken the candle for the measurement of incandescent lamps, and they have taken the French *bec* as the measurement for arc lamps. The Carcel burner is very nearly ten times that of the British spermaceti candle that burns 120 grains per hour and gives a flame 45 mm. high.

We have all these measurements taken; we have the energy transmitted to the machine, the electrical work produced by the machine, the ratio of the electrical work to the whole work put in; the useful work produced at the end, the ratio between this and the total work put in by the engine into the electro-dynamo machine; the velocity and the resistances. The magnetic measurements in all cases are made by Herr Von Alteneck's dynamometer, a particularly accurate and reliable machine, and they are represented in quantities that will be easily reducible to the new units. As regards the new units, I hope I have succeeded in inducing the Committee at Munich to adopt the new unit, the watt, as the unit of power. It is what we generally know as the

volt-ampère. In all electrical quantities where we multiply the electro-motive force by the current, the result comes out in a figure that we have hitherto called a volt-ampère, but now, and I hope in future, will be called a watt. It is an extremely easy thing to reduce this new unit of power into those that are known to us. For instance, supposing it is wanted to convert watts into horse-power, you simply have to divide by 746 $\left(\frac{W}{746}\right)$, and the product of the electro-motive force into the current gives a figure which if divided by 746 represents the horse-power; the same result if divided by the 736 $\left(\frac{W}{736}\right)$ gives the figure as *cheval-vapeur*; the same result if divided by 9·81 $\left(\frac{W}{9 \cdot 81}\right)$ brings out the value in kilogrammètres; and the same result divided by 1·35 $\left(\frac{W}{1 \cdot 35}\right)$ represents the value in foot pounds. So that when you have the product of the electro-motive force in volts, and the currents in ampères, in any circuit, and doing any work, you can readily and at once reduce it either to foot pounds, to kilogrammètres, to *cheval-vapeur*, or to horse-power, by the use of those coefficients. Therefore, when the results I have mentioned do come from Munich, I think we shall very easily translate them into our own language.

In conclusion, I have said a good deal of the efforts of these professors at Munich to obtain accuracy, and it is impossible to say too much of the zeal and activity, the work and industry, of Dr. Beetz and his assistants. During the time I was there they worked in a way which was worthy of example and worthy of commendation, and, as I have said before, their results will be worthy our most confident acceptance.

The real novelties in the Munich Exhibition have not been remarkably numerous, but the results of the Exhibition must be very good. In the first place, it must create an enormous spirit of emulation amongst the manufacturers of Southern Germany and of Bavaria, who flocked to Munich. Again, it must impart an enormous amount of instruction to our Bavarian beer drinkers on a subject with which they are so little acquainted. Although the Exhibition was neither international, nor can it be said to be

commercial, still it certainly has given thought to those who are preparing exhibitions in the future, to strike out new paths. Next year, I believe, we are to have an exhibition at Vienna; the year after, probably at Berlin; the year after, I do not know where; anyhow, I hope by that time that they will have to a certain extent ceased, and everything will have been shown that can be shown.

The great lesson that I learned from the Munich Exhibition was, that in the present day technical men are more exact than philosophers, and that the philosophers have been driven to adopt the principles of practice in their laboratories, and that even the philosophers themselves have been obliged to take lessons from such works as those which are brought out at the meetings of the Society of Telegraph Engineers and of Electricians.

The PRESIDENT: Gentlemen,—I will call upon any one of those six gentlemen whom Mr. Preece referred to as being ready to jump up and claim the priority of invention of certain things that he has described, to be so good as to jump up now as soon as ever they can and claim that priority, because, as the evening is getting late, and six may speak, the time is short.

Mr. R. E CROMPTON: As Mr. Preece has spoken so very kindly of my firm's exhibit at the Munich Exhibition, I think I should explain that the good result attained was greatly due to the energy of Mr. Bollinger and Mr. Chamen, who represented me, as I was unable to attend in person.

I believe that these gentlemen had great difficulty at first starting, as the engine supplied to them had no governor, which fact, to say the least of it, puts an electric light exhibition at a great disadvantage.

Later on I believe the engine worked better, but even at the best I do not consider that our exhibit represented our latest practice in a satisfactory manner.

I think it should be noticed that the firm of Messrs. Ruston Proctor, referred to in the paper, are very well known indeed. They do not happen, hitherto, to have been much connected with electric lighting, but I was very much surprised to see them spoken of in the *Saturday Review* as a firm unknown to fame.

I should mention one point in which I beg to amend Mr. Preece's remark, in which he says that the right place for arc lights is out of doors, and that of incandescent lights in doors. I think this should be as follows: all the lights may be used in doors, but the light *par excellence* for out-of-door work is the gas light! Its heat and headache-giving properties are there comparatively innocuous.

I have heard a good deal of Monsieur Cruto's new incandescent lamp. The idea is a very clever one. I have been informed, by Mr. Stearn and others, who have experimentalised with carbon filaments in vacua, that all deposited carbon gives a very much higher light-yielding efficiency than the natural carbon gives.

For instance, in the Maxim lamp the completed filament consists mainly of deposited carbon, the carbonised paper used being of little account. Virtually, the Cruto lamp will be of very much the same nature as the Maxim lamp, with this important difference, that the cost of the platinum wire employed by Cruto will go greatly against its being produced at a sufficiently low cost to be a marketable production.

Referring to the Schuckert dynamo machine, which Mr. Preece has praised so highly, I quite agree with him, but think we still should give the credit of its performance partly to Gramme, of whose dynamo it is a perfected pattern.

Mr. J. G. LORRAIN: I should like to make just a few remarks on the Berthoud-Borel cables alluded to by Mr. Preece, and which he spoke of as being Marshall's old paraffin wire encased in lead pipes. I have just returned from an examination of the Berthoud-Borel factory in Switzerland, and I know that in the cables, as manufactured now, no paraffin whatever is used, though in a form of cable formerly manufactured by this firm, cotton treated with a mixture of paraffin and colophane was employed to insulate the wire. The insulating material now employed is formed of oxidised linseed oil specially treated. Oxidised linseed oil, that is, linseed oil heated in contact with air until it assumes a gutta percha-like mass, has, I believe, been tried before, but as an insulating material it is far from perfect. By the Berthoud-Borel process, however, a very excellent and cheap insulating material is obtained. Linseed

oil is gradually heated up to a temperature of about 610° Fah., and at a certain stage of the operation, which the workman recognises by the appearance which the viscous mass presents, colophane treated with oil is added, and the operation continued till the desired consistency is attained. A firm, coherent, and elastic substance resembling india-rubber is obtained.

The most interesting and by far the most important feature in connection with these cables is the method of manufacture and the machinery employed therein. The cables are not manufactured first and then inserted in lead coverings. The process is almost entirely automatic: you literally see the wire passing into the machine at one end and issuing at the other in the form of a complete cable, protected by its lead sheathing. The lead is put on in a molten condition, and the cables can be made of any desired length, however long. When the cable is meant to be laid underground, it is passed through the lead press a second time, receiving a second coating of lead, with a thin coating of gas-tar between the two. Cables thus formed can be laid underground without being encased in iron pipes, and without further protection. The insulating material employed, as it is not affected by alternations of temperature, admits of these cables being laid in troughs along the curbs of the streets, and close to the surface.

A noticeable feature of the factory is its quiet and holiday aspect. This is due to the small number of workmen required to look after the machinery.

I should add that I believe these cables were very carefully tested at the Munich Exhibition, and the figures will doubtless be given in the official report.

Professor G. FORBES: Really there is not very much to be said in addition to what Mr. Preece has remarked about the Exhibition. He, with his usual tact, has succeeded in catching the whole of the principal things that there were visible at the Munich Exhibition, where I spent a week looking at what were the chief objects of interest. There are perhaps one or two things which I think Mr. Preece has not drawn attention to, probably because his time was limited, which I think have some interest, and about which he may perhaps be able to give us some information. One thing

struck me very much indeed, which was an instrument invented by M. Gentili, who called it a glossograph, a very remarkable instrument indeed, if it only does half that which it is said to do. It is an instrument with a number of springs fitted in different positions, which a person wishing to write shorthand inserts into his mouth. Some of these springs go back into the throat, others get mixed about the teeth and on the tongue, so that, while any one with an instrument so arranged is listening to a speech being made, he speaks the sounds into the instrument, and thereby moves little levers which press together electric contacts, and inscribe upon a sheet of paper various white lines which the transcriber is with practice readily able to read off. There is no doubt that this instrument was most beautifully constructed, but whether it was able to do all it was said to, I cannot say. The inventor was present occasionally, but I did not see him actually performing with the instrument; and if I had seen him performing with it, I should not have believed it, because he would only have time to speak a few words into it, which he would remember perfectly well, and there would have been no test whether he was able to read off anything which had been written a long time before or not. I was unable to get any further information about this instrument, and shonld be glad to know if Mr. Preece obtained any further particulars about it than I did.

To pass rapidly over the other things that occurred to me, there was one which I thought really worth mentioning, and that was the remarkably effective way in which the little theatre within the Exhibition was appointed. The stage was illuminated by the Edison people, but the requirements of the stage-manager were very stringent indeed, in so far that all the different lights in the flies, wings, etc., were to be raised or lowered separately in such a way that there were 20 different series of lights, each set arranged to be lowered gradually through 12 different ranges of illumination—that is to say, that the changes of illumination when the switches were turned were so gradual that they were quite imperceptible, step by step, to the closest scrutiny. It struck me that that was a remarkably well-designed thing, so new, and so readily according with the conditions laid down, that it was really deserving of some notice.

Another thing which has not been mentioned, which I think is worth speaking about, is the locomotive lamp which was shown. It was made by the firm of Schuckert, but I do not remember the name of the inventor. It had previously been exhibited by the Chemin de Fer du Nord at Paris. Some perfect demonstrations of the action of this lamp were given at Munich. It was really remarkable to see this electro-motive lamp with its reflector, in front of an engine, in spite of all the jarring and shaking of the engine, working as steadily as any electric lamp that I have ever seen. It was worked by a four-cylinder Abraham engine on the locomotive, and the lamp itself, though of an expensive form, was regulated by glycerine in two tubes. It is a focussing lamp, is extremely ingenious, and its steadiness during the whole of the journey to the Lac Tagansee, where I went on the engine, was most remarkably efficient. The only thing as a test of the practical value of this lamp, and one which I should very much like to see, is the effect of a similar lamp fixed on an approaching engine while one is travelling on an advancing engine; but the way in which such a lamp illuminated 300 or 400 mètres in front of an engine was very remarkable indeed.

On the other matters which Mr. Preece has referred to, I must say, with the attention that I paid to the Exhibition, that I agree entirely with almost everything that he has said.

As to the tests which are being made there, there is not the slightest doubt about it that the steps which were taken in preparation for tests, before ever the Exhibition was started, were most complete. A complete scheme comprised in the books which Mr. Preece has laid upon the table was arrived at and published before Exhibition was prepared, and the instruments were made and everything was ready for the tests before a single machine was in the building. From the moment the Exhibition began the tests were taken. I am glad to hear Mr. Preece say that we are to have the tests placed in our library. I had a little misgiving, judging by past experience, that they might not eventually see the light; but I think that, from what we have heard to-night, we shall, and that it will be a most valuable addition to scientific literature.

The Schuckert machine, which we are all perfectly well acquainted with now, has had some new and important modifications of detail. The details of the machine were certainly one of the most important things in the Munich Exhibition, and the attention which Mr. Schuckert has paid to the transmission of force I think in itself gave us a great deal of practical information which was very valuable, and no doubt, if the results of the trials at Hirschan be made known, they will give us some valuable results. There is no doubt that he does not claim, any more than the other illustrious firms who have worked in the path of the transmission of force, any such percentage of efficiency as Marcel Deprez does in his 57 kilomètre experiment; but it struck me that Mr. Schuckert's experiments of using water-power were far more practical and interesting in nature than that of Marcel Deprez, and especially in this point, that he has gone into the question of the relative sizes of the generators and of the motors which must be used, which is a question Deprez has left on one side. M. Deprez' experiment, which Mr. Preece spoke about, has been referred to in France and Munich in exaggerated terms, as though really it was a most wonderful thing, giving us information that we have never heard before. As a matter of fact, the efficiency of such a machine as M. Deprez has made, simply with a thinner wire, is an exact copy of a Gramme machine of the A type, the efficiency of which was perfectly well known. Then this experiment is announced as being the result of scientific calculation, and so forth, and that the machines were calculated to give such a wonderful efficiency for the double distance of 57 kilomètres for a line wire, using ordinary telegraph wire of 4½ mm. As a matter of fact, the machines were not constructed and not calculated on such a basis, but were intended to work with one ordinary wire 4½ mm., using the earth as a return wire; but when it was found that a second wire was necessary, the resistance was doubled, making the machines totally different from what they would have been had they been used for the purpose it was announced they were made.

Then, again, as to the efficiency of these machines, and the work which has been produced at Munich by the force of energy

which was put into them at Miesbach, that efficiency has never been mentioned yet as far as I know. I should be glad, and very glad, if Mr. Preece could give us any information on that point. As far as I was able to ascertain when at Munich, the only experiments made were to put a dynamometer on the machine at Munich, the motor machine, and to measure the number of revolutions in the machine at Munich and in the similar machine at Miesbach, and the ratio of those two was to give the efficiency of the machine. I am very far from being willing to admit that the ratio of the speed of these two machines will give us, even approximately, the efficiency of the machine. In the first place it implies absolutely that the magnetising force of the two field magnets, the field magnets at the two places, were exactly the same, which is extremely unlikely, owing to the inductive effect of the moving electro-magnets, and also owing, possibly, to other causes. It is by no means to be admitted that the efficiency is in proportion to the speeds of rotation, and therefore what should have been done (and what I have no doubt may have been done) was to measure with the dynamometer the force put into the generator at Miesbach, and measure with a dynamometer the force taken out at Munich. As soon as this is done I think it will be very interesting, and I should be much surprised to find that it was anything like the 60 per cent. Marcel Deprez has said.

Mr. ALEXANDER SIEMENS: In reference to Professor Forbes' remarks as to the arrangement of the electric light in the theatre at Munich, and the manner in which the lights could be turned up and down, I would recommend Professor Forbes to go to the Savoy Theatre, where the electric light has been in use for ten months. I mention this to place on record in the proceedings that the theatre at Munich is not the first in which the electric light can be regulated at will.

Professor FORBES: That is quite right.

Mr. W. H. PREECE: I take it that Professor Forbes simply wished to pass a tribute to the way in which the light was raised and lowered at the Munich theatre; but, unfortunately, I cannot support him in that, for the performances which took place while I was there were not very successful. They had not got their arrangements completed, nor their means of communication right.

I quite agree with Professor Forbes in his last remark about relative velocities on open wires being no indication of the work done on or by the machine. The velocity of the dynamometer at Miesbach was 2,200 revolutions, at Munich it was 1,500 revolutions, and these two were supposed to indicate the ratio of the power given out at one place to the power put in at the other; but there was no consideration whatever paid to the condition of the insulation of the lines, nor was the power put in measured at Miesbach.

If a wire be perfectly insulated, no disturbing influence exist, and if the two machines be identical at each end, then, if everything be right, the magnetic fields will be similar, and the velocity of the two machines ought to represent their relative efficiency; but if a leakage exist between wires, and a part of the current is lost, the result is a difference in the fields and an increased velocity at the receiving end, and it is therefore a mistaken notion to assume on an open wire that the velocities indicate the ratio of the work done. I pointed this out to Dr. Beetz, and I am quite certain that the Committee themselves will pay rigid attention to the state of the wires and to the proper measurements, by dynamometric measurements of the work done at each end, and not take the velocity as an indication of the efficiency.

The glossograph I did see. Like Professor Forbes, I did not see the inventor, but I saw a machine which had to be put in the mouth; and I thought to myself, when I saw the machine, that if the inventor supposed that when I came before the Society of Telegraph Engineers to give my experience in Munich, I would put that machine in my mouth, I would simply repectfully decline the operation—it would simply be a gag, and nothing more.

The wire of Berthoud and Borel is certainly an admirable wire: it is performing very well at Munich. How it will last I cannot say. I said that we were familiar with the wire before we heard of Berthoud and Borel: it is now said that, instead of paraffin, linseed oil solidified is used. We also knew that; for 20 years ago there was a material exactly of that description, called "parksine," which was an insulator composed of solidified linseed oil. But that does not detract from the merit of Berthoud and Borel—they have

introduced a new material in a new way; and, for electrical purposes, I fancy that they will succeed in producing a cable which will deserve a trial in England, and I wish them every success. I will not say any more at this late hour, but am much obliged to you for the kind attention you have given me.

The President: I will ask Professor Foster to move a vote of thanks to Mr. Preece for the interesting lecture which we have just heard.

Professor G. C. Foster, F.R.S.: Mr. President,—I have great pleasure in obeying your order to propose a vote of thanks to Mr. Preece for the address he has given us this evening. I speak as one of those who have not seen the Munich Exhibition, and therefore represent that part of the meeting which is under the greatest obligation to Mr. Preece. If he has not shown us the Exhibition, he has done the next best thing, he has given us a clear and vivid description of it. The attention with which he was listened to shows that I shall have the support of the meeting in moving, as I do, that the best thanks of the Society be given to Mr. Preece for his excellent account of the Munich Electrical Exhibition.

Dr. W. H. Stone: In seconding the vote of thanks to Mr. Preece, I should wish particularly to draw attention to that portion of his narrative which comes within my department, namely, the very interesting series of photographs which he has brought before us. Professor Von Ziemssen really is a forward man in the much-neglected branch of medical and physiological electricity, and he has here given us a series of pictures depicting the effects of the passions, as they used to be called, but produced entirely by stimulating the motor nerve of the muscles of expression. Some 50 years or more ago, grinning and horrible masks were in fashion, professing to show the effects on the physiognomy of various passions. In these photographs we have the same thing produced entirely without passion, by electrical stimulation of the nerve which controls the muscles. In this respect it is a considerable advance in what I have called a neglected branch of electricity. I may mention, also, that Professor Von Ziemssen has quite lately made some valuable observations, of which news has only just

reached us, and which promise to be of great importance. They institute a comparison between the continuous and the induced current in the stimulation of the important accelerator and depressor nerves which control the heart. He has found that an induced current, so far from stimulating, as we thought it did, the nerves of the heart, is perfectly inoperative, whereas a continuous current from an ordinary battery is of the very greatest activity.

The PRESIDENT: The vote of thanks having been duly proposed, seconded, and carried, I have only to speak for the meeting in offering Mr. Preece a hearty vote of thanks for his lecture, and also for giving rise to many interesting remarks from the various speakers who followed.

It is my duty to announce that on the 23rd of this month there will be another meeting of the Society. Before announcing the paper, I would like to say that there is one condition in the position of your President which I have found out since I have had the honour of occupying the chair, and that is that there is very little for me to say. The members always occupy so much of the evening, that when the end comes so little time is left, that if I had any remarks to offer I should not have time to make them. I suppose the Council has taken pity upon me. I thought I had escaped, and was out of the wood, and that I should very soon be your Past-President, and not be called upon to say anything more. But at the Council meeting this evening I was very much taken aback and very much surprised to be asked by the Council to endeavour at the next meeting to give the Society a short account of some of the telegraphic operations during the late expedition to Egypt. I can only say that I told the Council I should very much prefer not having to undertake it; but I felt that they had no doubt taken pity upon my silence, and pressed upon me the necessity of addressing you. I will do my best, and the title of the paper will be, "Notes on the Telegraphs used during the Operations of the Expeditionary Force in Egypt."

The meeting then adjourned.

The One Hundred and Fifteenth Ordinary General Meeting of the Society was held on Thursday evening, November 23rd, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Colonel C. E. WEBBER, R.E., C.B., President, in the Chair.

The minutes of the last meeting were read and confirmed.

The following transfer from the class of Associates to that of Members was announced as having been approved by the Council, viz.:—

T. Russell Crampton.

The SECRETARY announced that donations to the Library had been received from Dr. C. W. Siemens, F.R.S.; Lieut.-Col. C. E. Webber, R.E.; and Mr. Ladd—the latter presentation being the original letter of Herr Reis, written on the 13th July, 1863, from Friedrichsdorff, describing his telephone.

A vote of thanks was accorded the foregoing gentlemen for their presents.

Mr. W. H. PREECE, F.R.S., Past-President, then took the Chair at the request of the President, who addressed the meeting as follows:—

NOTES ON THE TELEGRAPHS USED DURING THE OPERATIONS OF THE EXPEDITIONARY FORCE IN EGYPT.

By Lieut.-Col. C. E. WEBBER, R.E., C.B., President.

Mr. Chairman and gentlemen,—The other day I was looking over some of the records of the proceedings of our Society, and other publications, on the subject of the use of telegraphs in time of war, and it struck me that old Father Time was rather an indifferent lineman, for he appears to have left his lines sometimes in what we call, telegraphically, out of regulation, at least in one respect. I found that, in the proceedings of our Society, the work, in connection with military telegraphy, of one of our oldest and most prominent members is not recorded. I speak of our honorary secretary (who, I am sorry to say, is absent to-night), Col. Frank Bolton. I am sure it will be gratifying to him to

know that the mention of his name was responded to. He is one who has rendered us very valuable services.

So early as 1855 I found records of his active mind turning to the subject of telegraphy, as applied to the uses of an army in the field. Up to the year 1860 he seems to have taken a great deal of trouble with the subject; and so early as 1861 it is recorded that he submitted his plans to the Government, and that his system of signalling and military telegraphy was practically tested by the Ordnance Select Committee at Woolwich, at the Crystal Palace, and at Southend—that trials were made before some of the most distinguished generals of that time, including Field-Marshal Sir John Burgoyne.

Encouraged by the reception which his proposals met with by such men as Col. Schaw, R.E. (who has been also well known as connected with military telegraphy), Col. Bolton continued his inventions, and I find that in April, 1862, he read a paper before the officers of Royal Engineers, at the Lecture Theatre at Chatham, on "Telegraphy for Navy and Army Purposes." He then brought forward a portable army electric telegraph, consisting of, instruments and a portable line. He claimed for his invention its adaptability for field service, for the purpose of reconnoitring, for mining purposes, for troops on the march, and he says, "It being acoustic, or oral, instead of visual, it may be understood equally well in a state of either light or darkness," and his proposal was described as "the adoption of a uniform system of telegraphy, the establishment of any system being better than no system at all."

In consequence of the very favourable reports made by those I have mentioned, Col. Bolton's suggestion was finally adopted into Her Majesty's service on the 30th March, 1863.

Soon after that, Col. Bolton became associated with Captain Colomb, R.N., with the view of assimilating procedure in the army and navy, and, the navy being preponderant (as I think in our country they ought to be), the adoption of a number code was decided upon. The proposal of Col. Bolton to use the Morse alphabet, as compiled by him, with a few additional signals, in 1861, was rejected.

So long as ten years ago Col. Malcolm and I read to you papers

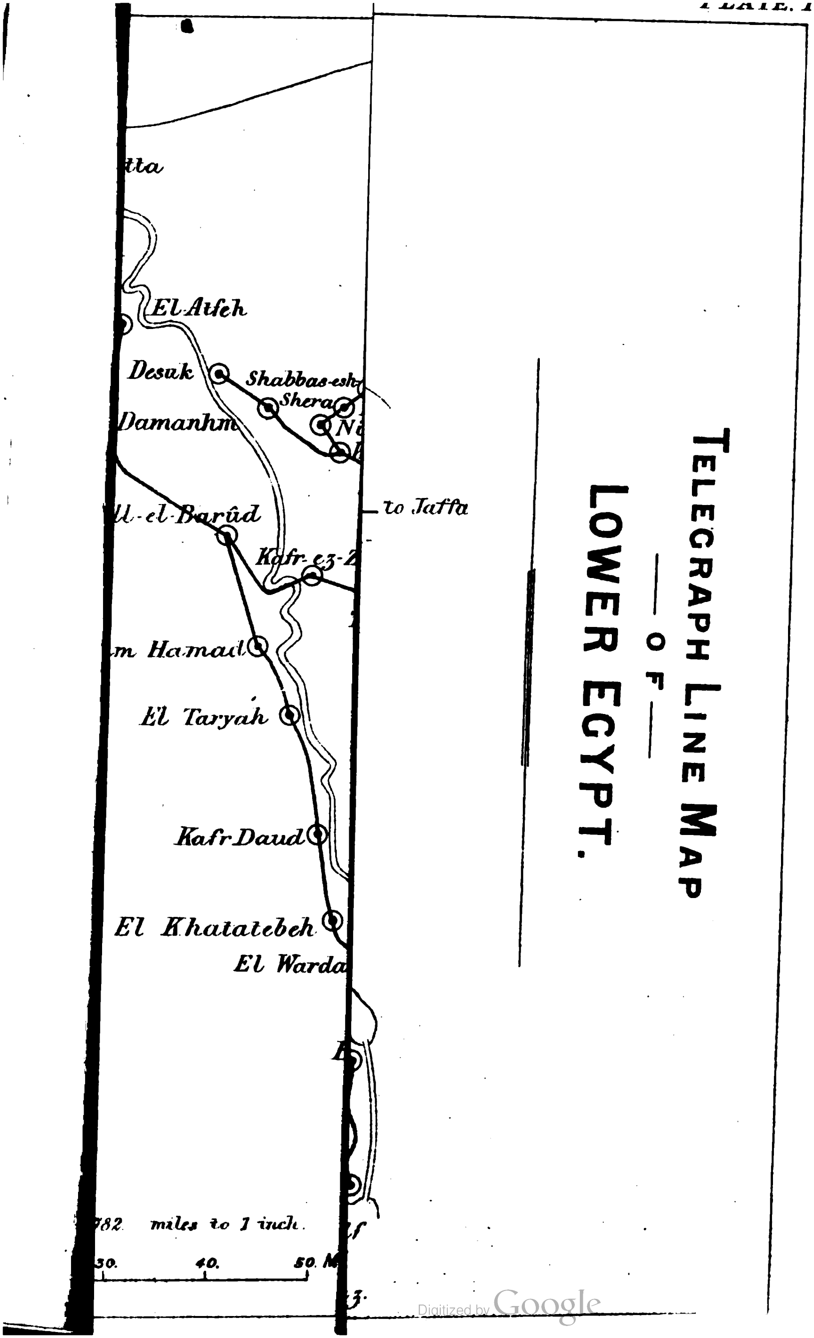
on the subject of practical military telegraphy. Col. Malcolm's paper chiefly consisted of a description of what had been done up to that time, and it will be found, on reference, that he divided his telegraphs under the four heads by which they have since been almost uniformly distinguished, viz., permanent telegraphs, semi-permanent telegraphs, field telegraphs, and visual signalling.

My paper was more a criticism on what had been done in the manœuvres of 1872, and very few proposals were made; but one, which then came home to me during the practical work, was, that the number code ought to be abandoned, and the Morse alphabet substituted.

In connection with the subject of signalling, which also became very prominent about this time, there were many officers of the army who, although good signallers, were not exactly telegraph engineers, but who fully coincided in this view, which by degrees (culminating in the year 1876, I think) became more generally adopted, so that for army signalling, as well as for telegraphy, the Morse alphabet came into use. Unfortunately, the language was not exactly made to coincide.

The officer to whom I have already referred, Col. Malcolm, I know, took with me, a great deal of pains in order to assimilate the procedure in signalling and telegraphy, *i.e.*, that the prefixes, the language, the mode of expression, the calling-up and all the smaller signs of telegraphy should be uniform; and, moreover (which is also important), that the message forms should be identical. A divergence, however, was authorised, which I think was unfortunate: this, I think, to a certain extent, has proved itself to be so in the late operations in Egypt.

In March, 1876, I again ventured before the public at the United Service Institution, and read a paper entitled, "Orders in the Field, and the means of communicating them." From that paper I will read one short paragraph, because I think it touches a subject of extreme importance; and although I may appear to a certain extent to differ from Col. Malcolm in the division of telegraphs under four heads, I do not know that there is very much real difference between us. What I said was as follows:—" The theoretical idea of a field telegraph at the front and an *etappen* tele-


Telegraph Line Map
— of —
Lower Egypt.
El Atfeh
Desuk
Shabbas-esh
Shera
Damanhm
to Jaffa
ll-el-Barûd
Kafr-ez-Z
m Hamad
El Taryah
Kafr Daud
El Khatatebeh
El Warda
782 miles to 1 inch.
30.
40.
50.

graph in rear of an advanced central point, is easy to write about, but very exceptional in reality. One wonders how any military student who takes examples from historical military operations, and considers how a telegraph might have been used in connection with them, had it been understood at the time, and, being aware of all the varied modes of such an application according to daily and hourly altering circumstances, could ever have laid down that military telegraphs should be subdivided in their working, material, or control."

The Egyptian telegraphs, I mean the Egyptian State telegraphs, are constructed on the model of those in India. I have no correct tables showing the mileage of line and wire, and the number of offices and instruments in them, but I show a diagram (No. 1) which represents a telegraph line map of Lower Egypt. Upper Egypt has telegraphs also which extend very far into the heart of the country; but such a map was not exactly necessary for the purposes of my address, and therefore I omitted it.

The instruments used by the Egyptian Telegraph Department are Morse printers, a sample of which was exhibited before this Society in 1872 by Col. Mallock, and you will all recollect that it was an instrument which we admired very much for its handiness and for its power of being used for several purposes. It was on a rather large square board, with the relay, lightning protector, and key, all on the same, and on the back side there was a small switch which is very simple, but which in practice, with those who have not been trained to the use of the instruments, has occasionally led to faults. The switch is intended for altering the instrument in its position, from terminal to intermediate. The wire used on the lines in Egypt is almost entirely No. 8 and No. 11, so far as I observed. The poles reminded one very much of the lines which any traveller can recall seeing in the Austrian dominions, viz., they were strong, serviceable, straight timber; barked, very clean on account of the absence of rain and wet weather, and above the average size used in this country.

The wire is suspended on insulators, I think mostly of what is known as Andrews' pattern, and these, being attached on alternate sides of the pole at considerable intervals, resemble the lines that

most of us knew when travelling through parts of France before the introduction of pole arms.

The battery universally used is the Minotti, and the rule for its use is very similar to that followed in India, *i.e.*, the line battery for 100 miles of No. 8 wire is 12 cells in dry weather, and 18 cells in wet weather.

A comparison, which will be useful to any one desirous of going into the subject, between the Minotti battery used by the Egyptian Administration and the Leclanché battery used on the military field lines (exhibited this evening), will be found in a paper read by Mr. Geo. Preece in 1873, in which the comparison of quantity appears as 160 Leclanché to 100 Minotti.

The telegraph line map before you has been copied from one supplied by the Intelligence Department, and so far it is, I believe, correct; but an accurate circuit map, to show the number of wires on any particular line, or as an aid to a telegraph engineer visiting the country, or wishing to know something about the telegraphs in it, was not in our possession. A circuit map was printed, but there were too many inaccuracies in it to be of any use. The real fact is this, that if you were to go into any country and try to obtain a circuit map, in very few systems are they complete; and in a country like Egypt, where there is every inducement not to undergo the discomfort of drawing a telegraph map, it is no wonder that none was accessible.

The *personnel* of the Egyptian telegraphs is composed of Europeans and Egyptians. The head of the Egyptian telegraphs is a gentleman whose name is better known perhaps in India than here, M. Le Mesurier: he is the chief of the railways, but the immediate head is Mr. Ernest Floyer, a gentleman well known in the East as a traveller, and the author of several most interesting works on that subject.

Besides the Europeans, who are all men of considerable experience, there are Italians, Germans, and French; but the main portion of the clerks are Egyptians, and, as a rule, I should think that 70 per cent. of them are unable to telegraph in any other language but their own. The linemen are almost entirely Egyptians, who are, of course, accustomed to the country. They

have little or no technical knowledge. I do not think there was a single man there who could test a line in the most ordinary manner; some of them do not even know how to make up their batteries, and none of them know how to repair instruments. But we must not forget that the telegraphs established in Egypt, probably in the year 1855, by, I think, Said Pasha, have had ever since to encounter the difficulty of obtaining sufficiently educated Egyptians to train, and I think that the devotion of these men, in many cases, to their work, and their hard work, compensates a great deal for their ignorance.

On the right of the diagram will be noticed a place called Kantara, on the Suez Canal, whence a line is carried to the east. That is the Syrian line, which connects the Egyptian system with the Turkish system, and, as far as I recollect, it consists of four wires. The same number pass under the Canal by an armoured cable. How much further in that direction the Egyptian dominion extends I am not sure.

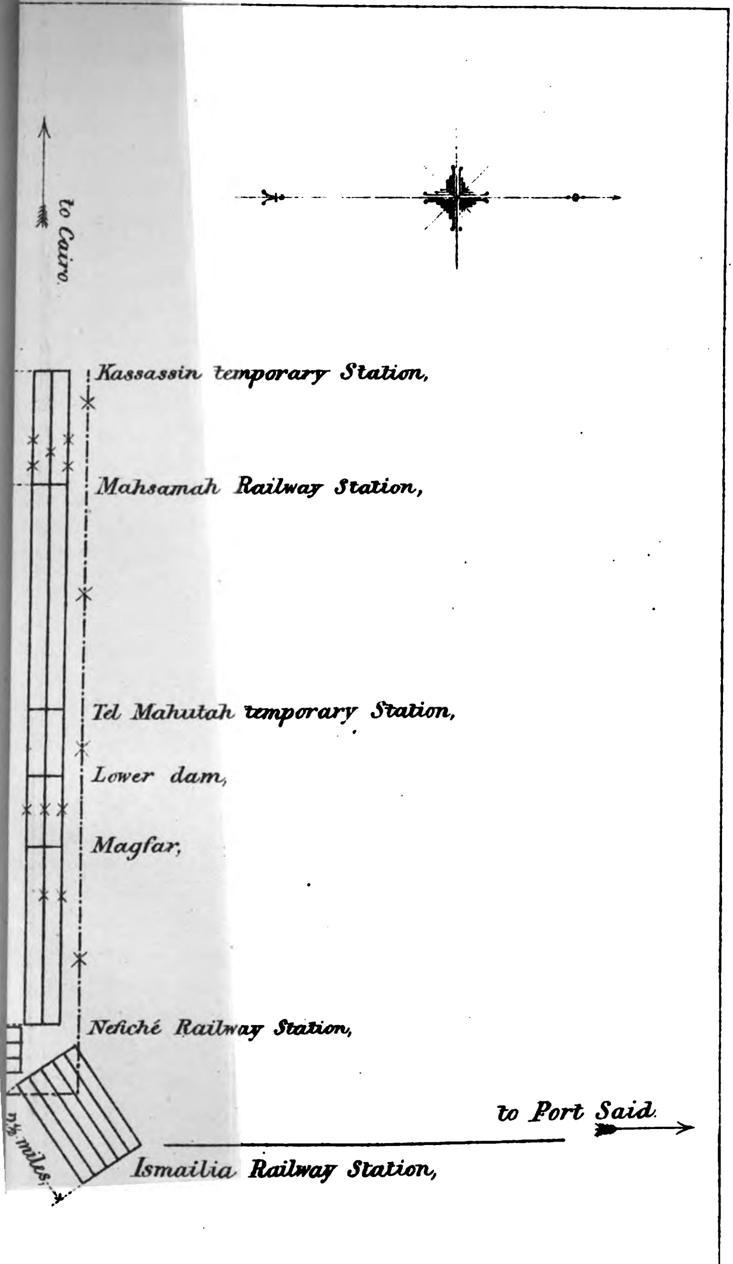
We have heard a great deal lately, and I have read some very interesting accounts to-day, of the loss of those distinguished men, Professor Palmer and his comrades, Mr. Charrington and Captain Gill. I have seen it stated that one of these officers had a mission to cut the telegraph line to Syria, east of Kantara, and I can only say I cannot believe it. It has never, as far as I can make out, been authoritatively confirmed, and therefore I prefer not to believe it. Now, if you come to consider that Moses' Well is directly due east of Suez, and that the line to Syria was about 50 to 60 miles north of it, I do not think that the party would have gone to Moses' Well first,* in order to cut the line north-east of Kantara. This increases the improbability. Again, I cannot for one moment understand why the line should have been cut. If it was necessary to destroy the line, supposing that the desert to the east of Kantara was in the possession of the rebel Egyptians, I can understand that it would have been a very gallant thing to make a raid into the desert and deprive them of its use; but considering that there was little or no enemy in the desert, and that there was even an

* They started from Moses' Well the 11th August.

advantage in not cutting the line, I do not myself believe that the mission ever really was intended to do so. Of course, I am only speaking as a matter of opinion, I know nothing whatever about it; but what I think under the circumstances would have been the right thing to do, was to have waited one week till the night of the 19th August, when the fleet occupied the Canal, and then have obtained telegraphic command of the line at Kantara, which became a very strong military post, where nothing possibly could occur without the permission of the naval officer commanding.

Another interesting system of telegraphs exists in Egypt—I mean that belonging to the Eastern Telegraph Company. I have shown it on Diagram No. 2, or so far as it affects that portion of the system, by a dotted line. There is a line of two wires on iron poles which extends from Alexandria along the railway throughout by the east side of the Nile to Benha, through Kalyub to Cairo, where it comes out, and passes again through Benha and El Zagazig to Nefiché, where it turns southwards to Suez. It is a very well constructed line, but the climate is against it, owing to the excessive loss of insulation from dew, with iron poles. The Eastern Telegraph Company, before the war, had three stations, at Alexandria, at Cairo, and at Suez. The ordinary maintenance was done by the Egyptian Administration. I believe a free way-leave, or what was the same thing, was given to the Company along the Khedive's railways. Up to the war they had no line along the Canal. Their lines seem to have been the object of a certain amount of animosity on the part of the Egyptians, probably because they belonged to Europeans. On the whole, I think they were the most damaged lines of all those that were injured.

The meeting is perfectly aware that during the war a cable was laid from Alexandria to Port Said, with the view of completing the communication to that place. Up to the 25th August the cable station at Port Said was about four miles out at sea, but on that date the shore end was extended, and an office established at Port Said, a few yards from the Egyptian Telegraph Office. Of course, when the Eastern Telegraph Company had a cable from England to Port Said, its object was to get a line along the Canal as far as Suez. It can well be imagined what an amount of delay


to Cairo.
Kassassin temporary Station,
Mahsamah Railway Station,
Tel Mahutah temporary Station,
Lower dam,
Magfar,
Nefiché Railway Station,
to Port Said.
Ismailia Railway Station,
2½ miles.

and inconvenience must have occurred to their traffic when their lines through Egypt were broken down. No doubt they were able, with the delay due to sending the messages by boat along the Canal, to carry on their business, but there was always that delay. The first object, therefore, on arriving at Port Said was to get a wire to Suez. At Suez they had an establishment under a gentleman who is well known to many of us, Mr. Tuck (at least I believe it was under him), and on the arrival of Admiral Sir William Hewitt and the Indian Contingent, the officers of the Eastern Telegraph Company rendered every assistance that they possibly could, and supplied some of the minor wants of the army by establishing telephone stations in Suez and the neighbourhood. Again, these gentlemen offered every assistance when Brigadier-General Wilkinson marched along the railway from Suez to Nefiché. When he went north from Suez he was accompanied by some officials of the Company, who made it their business, with the assistance that the army could give them, to repair the line in several places. There are two lines in that section, one, that of the Eastern Telegraph Company, the other, the Egyptian line. Curiously enough, the Arabs had destroyed six or eight miles of the Eastern Telegraph line, apparently for mischief, and in order to make a branch line at another point, had pulled down about six miles of their own line. However, as these two breaks did not coincide, it became possible to maintain a continuous wire throughout. One of the gentlemen who accompanied Brigadier-General Wilkinson was Mr. Chamberlain, who rendered every assistance that he could, and the line was made good as far as the junction at Nefiché (see the map). A connection was made on the 31st August, but at the junction pole some mistake was made, and the wire was not through.

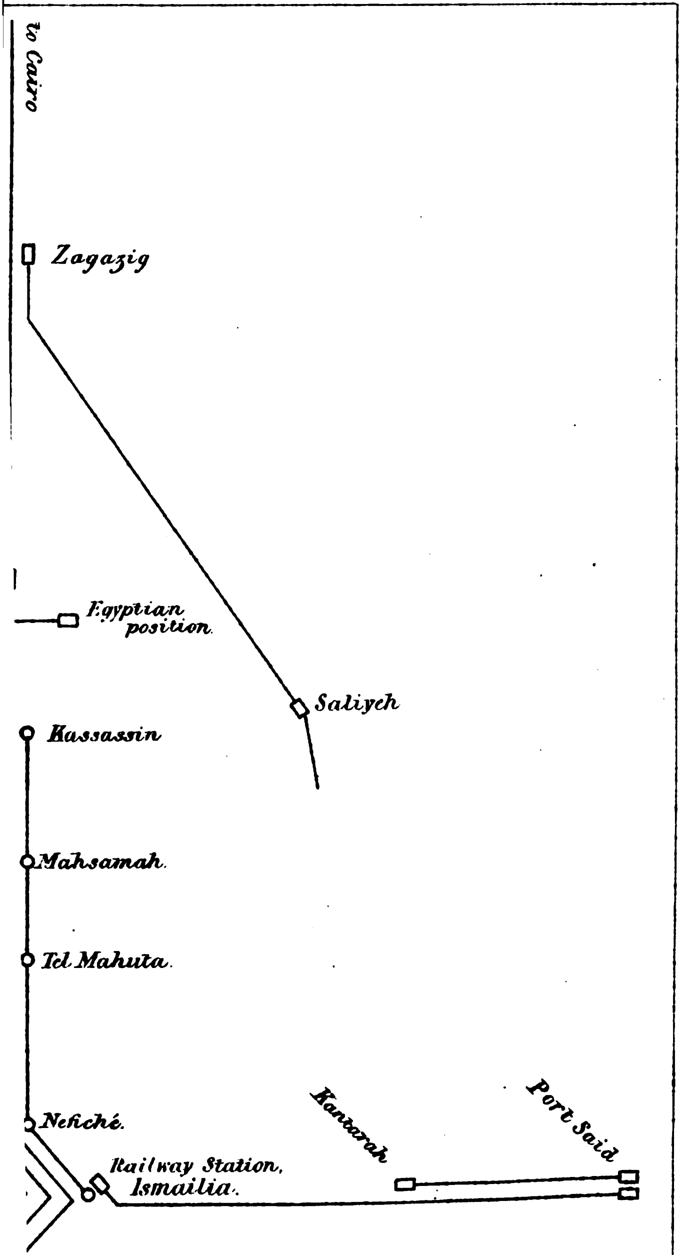
Very soon after the arrival of the army at Ismailia, it became necessary to defend the Suez railway from the inroads of the Bedouins, which were continually taking place, and armed posts were formed at each of the four intermediate stations, where telegraph offices also became necessary. The mission was very successfully accomplished by some of our Telegraph Corps, who travelled upon the Canal at night with a very small escort (a large one was not

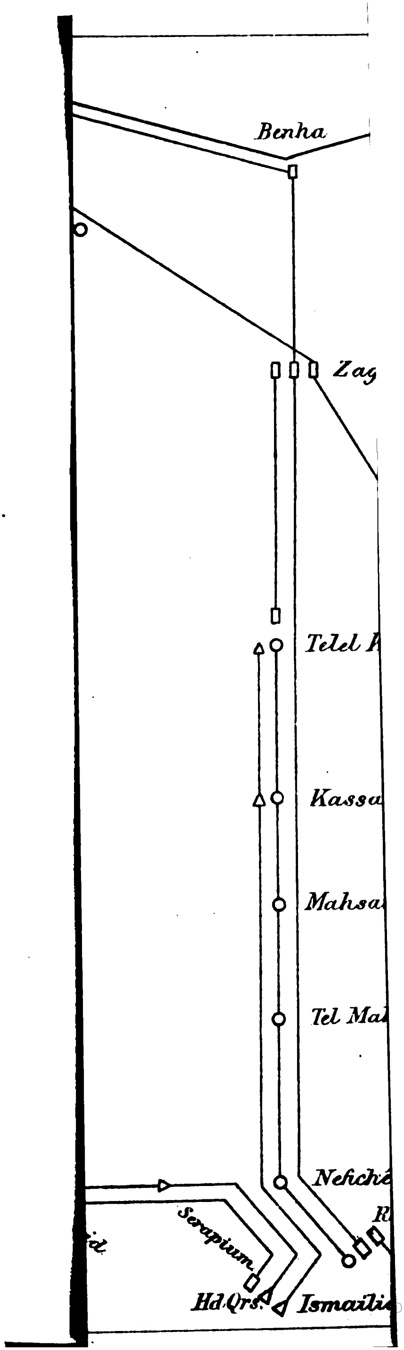
necessary, certainly), in a steam launch, with tools, apparatus, and batteries, and landed at each point in spite of the difficulty of crossing the Sweet Water Canal, and wading through the deep sand (in one case 7 miles), established their station, left their clerk, and returned, the whole being accomplished in two days.

Another line of telegraph exists in Egypt, which is one belonging to the Suez Canal Company. It extends from Port Said to Suez, with stations at every "gare" (as the stations are called) where the Canal is widened. Throughout the line there is a through wire, and another with the intermediate stations upon it. I dare say it is well recollected, for it was a matter of common newspaper report, that the Suez Canal Company was not very favourable to the expedition; but as we had not conquered Egypt, and did not appropriate any of the things which did not belong to us, it is easily understood that we did not appropriate the telegraph line, the property of the Suez Canal Company; and I may say this, that as they became aware of the mildness of the intentions of the British, their views to a certain extent changed, and they often forwarded and received messages from those who guarded the Canal, in the kindest way.

There is one thing in connection with the Canal which I do not know has been mentioned in the newspapers, but at the same time which is worthy of mention, for although the meeting to-night is not a naval one, still we are all glad to hear of anything to the credit of that service. The Canal, as I dare say the meeting is aware, was guarded by the navy, and all along that burning arid bank were stationed small parties of blue jackets and marines under officers, and twice a day these men marched from one place to another and back again; and I assure you that when one went along the Canal it was an exhilarating thing to see those cheerful lads going along, singing songs, at a pace through the soft sand which could be exceeded by very few. It was very dry, dreary, monotonous work, but they did it as only British sailors do everything they undertake.

Diagram No. 2 is simply one showing the actual wires that came into use for military purposes, and it almost explains itself.


to Cairo
Zagazig
Egyptian position.
Saliyeh
Kassassin
Mahsamah.
Tel Mahuta.
Nefiché.
Railway Station,
Ismailia.
Kantarah
Port Said



Benha
Serapium
Hd.Qrs.

It merely gives the number of wires between the points shown coming within the area of the first operations.

One of the intentions of the military authorities in Egypt was to restore to the Egyptian Administration as rapidly as possible the telegraphs that they had worked before the war, and which were their property. Therefore, as soon as that could possibly be done with safety to the wants of the army, it was so.

But, on the other hand, there were certain drawbacks, and this had to be done with caution. The Egyptian Administration had become very short-handed: the telegraph clerks, mostly Egyptians, had gone over to the enemy. The European clerks had, many of them, left the country, and at first it was very difficult indeed to obtain clerks to work the line from Port Said to Ismailia. But by the 28th August that line was handed over to them, and thenceforward all messages going to England were transferred from the military lines to the Egyptian, and the manipulators at Ismailia railway station and Port Said belonged to that Administration. If they had had more English-speaking clerks no doubt we should have sooner been able to transfer the lines to hem, but an Egyptian clerk, although he can forward perhaps 20 o 25 words a minute in his own language, can rarely exceed 7 to words a minute in English. Of course this, as you will presently ee, was totally insufficient for the wants of the army.

Diagram No. 3 is a circuit map of the lines that were in use revious to the day of the battle of Tel-el-Kebir, the 13th eptember. Diagram No. 4 is a circuit map of the lines, which hows their disposition after an interval of two or three days ter the battle.

The railway station at Ismailia was about a quarter of a mile om the Headquarters, and at first, as long as the General Comanding remained in Ismailia, all the lines, with the exception of at to Port Said, were led into the Headquarter office. A regular stem of handing over to the Port Said line by messengers was tablished, with a delay of not more than 10 minutes on each ssage. The wire to Suez was, as I have said, partly on Egyptian les and partly on the Eastern Company's poles, and its termina- n at Suez was in the Eastern Company's office, not in the Egyptian

office. An omnibus wire with four intermediate stations follows the same line, but was broken down, and therefore not used beyond Shalouf. The military field sounder (of which there is a pattern on the table before you) was placed at each station with a relay, and the only Europeans (because there were native troops employed), besides the officers in command, were the Royal Engineer clerks, who found themselves in the middle of the desert under difficulties. They had not too much food, and were short of message forms, and, above all, of candles, things not very easily got in a desert.

One of the wires to the front had to be used for railway purposes, and it will be seen marked on the diagram, with single needles upon it. Another of the wires was used for ordinary traffic, and the top wire was kept especially for the purposes of the General Commanding, at least that was the intention; but of course in telegraph offices messages are generally sent off on the wire that is free for the time being.

I will pass over the events of the first days of September, and go on to what occurred on the 13th. The night before the battle the terminal office was at Kassassin; the line was believed to be continued into the position of Tel-el-Kebir, and onward. Arabi Pacha had communication with Cairo by two wires, and he could transmit to Saliyah, where he was believed to have a force, by Zagazig. One of the wires from Cairo, coming round by Benha, was continued to his camp, where a telegraph office was established in a tent. The line is of course exaggerated on the map, as it was in reality not more than a mile long.

The General Commanding was desirous of being able to communicate by telegraph between his flanks, and that with other work was undertaken by what is called in the army the Field Telegraph, under the direction of the officer commanding C Troop, Major (now Lieut.-Colonel) Sir Arthur Mackworth, R.E.

It was of great importance to push on with the army (and of course we assumed that victory would follow, and that we were not going to be beaten), to enable communication to be kept up, and to do this it was advisable to reconnoitre. The line had been reconnoitred by cavalry and various people, but as a rule I find

that you require somebody who has a little experience, though it may be very small, to come back and say what state a line is in. I dare say many a telegraph engineer has found it extremely difficult to get an accurate survey of a line—not that people cannot, but somehow they do not, and leave out essential things. As this survey was connected with my duties, I determined on leaving the camp after midnight to reconnoitre the line, which I did as far as one could in the dark, and by following it closely and slowly. It was just not too dark, and that was all, and I was able, by looking backwards and forwards, to mark the poles and examine the spans from Kassassin. The line was pulled down in one or two places: the top wire in several places; the second wire was good nearly throughout; the third wire was pulled down in two places. This was probably the intentional work of the Egyptians, or else the wire had been cut by the bursting of shells in its neighbourhood. Of course in going on one did not very much see where one was going, and at a certain hour in the morning it was necessary to retreat, because it became *a little too hot* to be pleasant; but as soon as daylight came on it was perfectly possible to proceed with the advancing column, and reconnoitre inside the position. Naturally, I am telling you very much what occurred under my own eyes. I made for what I had my thoughts on all the morning, the railway station at Tel-el-Kebir. I knew that I should there find very much how matters stood. Just outside the station all the wires were broken down for seven or eight spans. The office was in the state in which we found all the rebel offices in Egypt, *i.e.*, in dire confusion. When discipline was removed from the Egyptian linemen, they neglected their work: the batteries were unrefreshed, the sawdust was dry and clogged, the zincs and coppers were not clean, the leads were all mixed up. The offices were filthily dirty, paper and rubbish were strewn about in every corner, old clothes in one place, boots in another, and so on. Of course, arriving in a telegraph office in such a state, with just, as it were, the odour of Arabi's clerks remaining behind (for they had not escaped ten minutes), it was a little troublesome to get the office right. I enlisted to my assistance two very smart Highlanders, who were still labouring under the excitement of the attack in which they

had just before been engaged: they worked with a will, and in two hours the office was in a very fair state. All the leads, which had been mixed up on the roof, were put so far right that the line was sufficiently repaired to speak to Cairo and to other intermediate places. As soon as I had put the wires through on the roof, calls were received on one instrument. These calls I watched, and saw at once that they were not those of English clerks. Fortunately, at that moment a very intelligent officer of the Egyptian telegraph service came in, a Mr. Clark, attached to the Intelligence Department, and knowing him, and also knowing that he could speak in Arabic on the instruments, I asked him at once to reply. He did so on one, and said to me, "I have got Cairo." I said, "Don't answer him." He then went to the other instrument, and said he had got Benha, and asked if he should say who we were. I answered, "By no means; say nothing about it." He then obtained Zagazig, and said, "I know this chap," and went on talking to him. I said, "What are you saying—that we are here?" He said, "Oh yes; I am telling him to be a good boy and we will not shoot him." Mr. Clark was then called away, and I was left alone with my two Highlanders, and refrained from any more conversation, because I believed it would only do mischief. However, we knew that the wire was all right onward, and left it so.

My duty called me back to Kassassin, where of course the great congestion of traffic existed. The Kassassin office was a very curious scene that day and night to the telegraphist. In the first place, the heat in the tent was intense; the flies covered almost everything, the faces and hands of the Sapper clerks, and every part of the instruments and batteries. The batteries were every now and then giving out on account of the intense heat. Many people were coming to the office paying for messages, with the appeal, "Do take my message—pay anything for it;" and from the front mounted messengers were coming in with affectionate messages from various members of the army to their friends at home, telling them that they were quite well, and that they had escaped, and so forth; and of course some were messages of a different kind. You all probably recollect the morning in London, and

you can perfectly well understand that, as the news flashed over the country, every affectionate relation and every loving heart wanted to know how their dear one was, and sent a telegram; and these poured in from the other end till at last messages came from Port Said and from Ismailia, to say that they did not know what to do, that the line was blocked, and that there were 14 and 20 hours' delay, which under the circumstances you can readily imagine was the fact.

I will now pass over the interval between the 13th September, the day of the battle, and the 16th, when good communication was at last established—when the main part of the army had advanced with the headquarters to Cairo.

An interesting thing to those who care for these matters occurred on the 16th. Looking at the Map No. 4, a line of two wires will be seen leaving Cairo, going by Belbeis, passing through Zagazig, and so on to Kantara. Previous to the 9th September there had been instruments there which were occasionally joined up to those wires. There had been some suspicion (purely groundless) of foul play going on, and that some Egyptians, whether in the clouds or the Canal, or somewhere, were communicating with somebody else in Cairo. It is very curious how soon there is a panic, and an idea that something is going wrong, if an instrument is seen to move of its own accord. Of course any one who understood the thing would know that the signals were calls from a distant station destined to find out if any friends were at the instruments on the line. I think it was on the 9th September that, to prevent the possibility of this, and by some misunderstanding, about a quarter of a mile of the line was pulled down and well destroyed. There was a little mania for demolishing lines early in the war, and so well was it destroyed that the poles and wires were almost cut up into mincemeat. When knowing this, headquarters having reached Cairo, it struck me, of course, it was all important to get a through line thence to Port Said. I therefore by night, in that most beautiful of all means of travel, a torpedo boat (I do not mean one that will blow up, but one of the most delightful modes of locomotion on the water that you can imagine), went to Kantara, and there, by the aid of those excellent men

(they will do anything), the blue jackets, put that line through. We did not, of course, put poles up; we screwed the insulators into the stems, and carried the wire along the sand, which made very fair insulation. I had no means of ascertaining if the line was working successfully through; but two days after, at Cairo, I found that the moment the work I have just spoken of was accomplished, they found themselves suddenly speaking to Port Said, and the congestion, which had then reached a very high state of tension, was immediately got rid of.

One important work of telegraphs in connection with an army in the field is the line of telegraph to be used for working the railway. In this case it was only possible to give the railway department one wire, and not even could be given to it the exclusive use of one. This, as you may imagine, was not handed over to them, because they had no clerks; it was simply worked for their purposes. The working of that railway was, I think, a most remarkable and curious thing, and of the most interesting kind. How in the world they did not have an accident every day I never could make out. But yet there was precision and care; they moved of course very slowly, and everybody took the greatest pains. I assure you if any one in this room had seen the officers, non-commissioned officers, and men of the Royal Engineers working as they did that railway, as if they felt their very lives depended on it, they would have been filled with admiration. Here were men standing out in the blazing sun at their *points* all day (some had rigged up, perhaps with their rifle and two sticks, a little covering over their heads by means of a pocket handkerchief), but there they stuck to it, and I don't believe were ever relieved. You may talk of pointsmen in this country and their hardships, but I can see no comparison with those. In the same way the guards and engine-drivers and each man stuck to his work in a way that I confess I never encountered before. Of course the telegraph was very necessary, and did afford a considerable amount of assistance; but any one who has had to do with railway wires in this country, and the maintenance of lines worked on them, must be perfectly aware that a stationmaster requires a certain amount of experience as to how he should use his tele-

graph. I think it is *very often forgotten* that the possession of a telegraph *is not all, but that you must know how to use your telegraph.*

Well, when a telegraph clerk in an office such as I have described (there were two permanent railway station offices, small huts, and two tent offices), covered with flies, and with a needle instrument such as those used, which were of the old double drop-handle pattern, and were sadly out of repair, receives perhaps 20 messages all at once to send off about one train, or 10 messages, or even 5, you can easily understand that he is a little puzzled as to matters of code, time, and so forth, and that it is very probable, as often occurred, that the train may arrive two hours before the message about it, which was a mere nothing. Remember that I am not for one moment implying blame to any one—only inexperience. I only know that the stationmaster had orders to advise the passing of a train as quickly as possible to ever so many people, and he carried out those orders. It did not, however, follow that the message of advice to the next stationmaster was sent first, and it therefore often arrived too late. The use of a telegraph is one of the experiences of a stationmaster, and a very necessary one, and may not often be thought of. Most of us recollect the fearful accident which occurred at Norwich, where I believe the verdict was to the effect that the accident was almost entirely due to a mistake in the telegraphic capabilities of a stationmaster, though probably a man of very long experience.

The railway instruments used in Egypt, as I have said, were double-needle instruments. The fact was that the instruments which ought to have been used were probably at the bottom of a ship somewhere—of them I will speak in a few minutes. We were obliged to alter the double to single-needle instruments, as the only resource. They had to be put on, in the first place, while they were still out of order, in the absence of good mechanics before the 30th August. The time that would have been occupied in exchanging the needles for our own instruments could not be afforded. One thing which ought to have been tried (it would have been interesting) was to ascertain if we could have got a return earth for our circuits by the rails. I am not quite sure whether they

were joined throughout by plates, but I am pretty sure that the thing was never tested to any great distance, though, considering the difficulty we had at all stations in finding earth, it would have been a useful experiment; but on such occasions it requires readiness of resource and great experience really to experiment without breaking down the working circuits.

The military Morse inker* on the table is an extremely convenient one for railway purposes, if it is joined up in closed circuit. You all know that the form is very commonly so used in America, and if we had had some of these instruments on the railway line in Egypt, instead of the single needles, I think but little, if any, delay would have occurred, except perhaps on one occasion, when one of the railway offices forwarded over 60 messages in one day, and that during the busiest hours. Those gentlemen who are interested in the form of construction of this instrument, and like to examine it afterwards, can, by reading the inscription upon it, easily see how it is changed from intermittent to closed working. The advantage is that, before working, the clerk cuts the closed circuit by lifting the key with his thumb. Every instrument along the line is similarly disconnected, they all print alike, and as no relay is necessary their adjustment is simple. The working of the closed circuit might be objected to on account of the battery expenditure, but I do not think experience has shown that to be excessive. I find that some years ago, in India, Professor Ayrton made a report upon this point, and his expression was that the expenditure was only "rather more."

The details of the *personnel* and equipment which was sent from England, and which was probably the best that ever left these shores, would be a matter which would occupy too much of this evening. I will just draw your attention to one or two articles that I have been allowed to bring here to-night.

In the first instance, the pole line. This pole line and the insulator are the outcome of very great deliberation with reference to weights, portability, and other matters. The insulator, of which

* This instrument was the outcome of the deliberations of a Committee which sat in 1879, of which Colonel Crossman was the Chairman, and Major Armstrong and I members.

specimens are on the table, is of ebonite, with a brass cap, and I think there is not a single want that is not provided for. The shackle, a nice handy little article, is also very useful. It can be used for a light military line, and also for a heavier wire if necessary.

The poles are conspicuous by their black and white bands, which, with the colouring of some landscapes, is most useful: it enables one to see the line at a considerable distance, and of course it is more important that you should see your line than that your enemy should not see it. These poles are also sometimes useful, as showing difference of level.

In India I believe that these light pole lines have been tried, both in Afghanistan and in several of the hill expeditions. I do not know whether the poles were of the same length or strength as those before you, but one very good rule was found there to be of great use, which was, that the line was inspected in sections from two to three times a day. Such a line is not able to withstand the attack of pack animals, or of animals running away, and in several cases, even in the short time that we were using sections of these lines in Egypt, where we replaced the wrecked Egyptian lines along the railway, these poles were knocked over by animal traffic near the permanent way, for, as you can imagine, the railway was the track most used by all.

I believe myself that lines constructed with these light poles and light wire can be made very strong, and I should even go so far as to say that there is hardly a limit to the strength with which you can construct such a line; but when men are working against time they are disposed to be satisfied with just sticking the butt into the ground to a certain depth, and not staying it sufficiently, the consequence being that it is very easily knocked down, and what would otherwise be a very good and serviceable line becomes a very troublesome one. It can be very well imagined that, after a section of such a line has been erected, and a good many poles having been knocked over and only partially repaired (because linemen never repair half as well as the original construction party), the line becomes in time very shaky and faulty.

The field printer is, as I have said, a very convenient instrument. I do not think that, if any of you were to search any equipment in Europe, you would find an instrument which altogether answers so well. It worked most admirably in Egypt, and I do not think there was a single objection made to it in any particular instance. The resistance of the coils is 300 ohms; the resistance of the little galvanometer, which is very beautifully made, is 26 ohms.

Attached to the printer is a very good lightning-conductor, and all the connections of the instrument are very simple; they are very accessible, and the lines of inlaid wood seen on the board show the connections between the terminals.

The field sounder which I have shown you is also a very beautiful little instrument, and its resistance, Major Armstrong, R.E., informs me, is 300 ohms, and the galvanometer also 26 ohms.

I have already mentioned the difficult circumstances under which the military clerks in the telegraph offices did their work, and the meeting can readily understand that it was extremely trying. I remember going one day into one of these offices and watching a man whose hands were fully engaged, and I calculated roughly that there were 20 flies to the square inch all over his face and hands, and this busy fellow, instead of using his hands to brush off the flies, continued steadily at his work.

The officers and men of the Telegraph Corps employed on the outside repairs and construction of the lines had hard work. It came before me very prominently that the work of a man in that climate, doing his best, was about half the work of a man doing his best in this climate; and, only, if a man was not given to consumption of liquid, was he able to stand the terrible thirst that comes on after an hour or two's exposure to the sun, dust, and sand.

Nothing could exceed the energy and good conduct of all ranks, in common with that of the whole army.

There were one or two points which struck me as being good practical hints to those who have to decide on these matters. One, regards (though I do not believe it would apply so much in a cold climate as in a hot one) the half-mile coil of wire. When men are constructing field overhead lines they carry the coils forward,

and it struck me that half-mile coils were rather too large for them to handle easily, and that quarter-mile coils would be better.

The pole-climber, which was a very important implement on the tall Egyptian poles, was not convenient enough for such a climate. I remember, there was long ago a controversy, as to whether the shank of the pole-climber should be on the inside or outside of the leg. I watched men climbing poles under the circumstances I have described, and it struck me that the shank should certainly have been on the inside and not on the outside. I believe the approved pattern is the outside.

The battery used for military purposes is a Leclanché in a wooden box. Parts of the cell are on the table, and the cell itself is closed by a mixture of tar; and the only inconvenience encountered in connection with its use in Egypt was that the tar sometimes melted, through temperature, and ran, so that, when the battery was in course of transit by waggon or packed on board ship, it became unserviceable.

The great advantage of a Leclanché battery for military purposes is that it is a one-fluid battery, but there are well-known difficulties in connection with the use of it, one being that, when it is used as a local, or for a busy circuit, or, still more so, when it is used for a closed circuit, it rapidly runs down.

I have been led to think over this question of battery maintenance in a hot climate, for military purposes, and while doing so my friend Professor Fleming has brought me a battery which I am in a position to show here to-night, and which I will ask those who are interested in the subject to look at after the meeting. This battery is composed of six large Leclanché cells. They are sealed at the top; the terminals are clamped together by binding screws. The frame which holds them together is partly of wood and partly of metal, but I do not think that Professor Fleming adheres to that form. There might be many forms of framework for attaching the cells to one another, and they could be held together in varying numbers as might be required. Professor Fleming has favoured me with a description which I will give, because I think the subject is of great moment:—"The electromotive force of these cells, as tested before they were brought here,

is 1·5 volts, and the internal resistance is a little less than 1 ohm." He agrees with me that such a battery would be of great use (for reasons which I shall mention in a minute) for field telegraphs, and as put together in a set of six. "The elements of this battery are a modification of the Leclanché (of course it is a Leclanché). The cell is divided into two parts by a porous septum. One side contains a zinc plate fitted in a groove—the plate does not reach to the bottom of the cell; the other side contains crushed carbon and manganese peroxide. The carbon is, however, previously prepared by saturation by a solution of bichromate of potash and dilute sulphuric acid. The carbon being saturated with this enables it to depolarise more quickly than in the ordinary Leclanché, and also the ammonia formed combines with the free acid and forms ammonia sulphate. The partition in which the zinc plate is placed is filled with muriate chloride solution. Fitting the zinc plate in a groove prevents it from knocking against the porous partition and breaking it."

The chalk drawing on the board is sufficiently explanatory, and you will see that, although full of liquid, you can shake the cell [does so] as you like, and there is not the slightest particle of leakage of any kind. The absence of leakage is due to the material of which the cell is made, which is insulite, and the plate which is laid in on the top is also insulite, and is soldered into its place.

For military purposes there are certain advantages in this battery. Of course the main one is its freedom from waste or injury by the action of heat: the insulite has actually been boiled, and no impression whatever has been made upon it. There is no approximate liability, certainly, to fracture, and of course, in consequence, it can be carried in a light framework of the kind you see, which dispenses with the necessity of having a box and a cover. It might be said that it may be necessary to protect the binding screws, but even these are unnecessary. The two little attachments can be bound together by very much more simple means than have been resorted to in the arrangement before you. These batteries are at the moment in action, and to show there is no delusion, you see I can ring a bell from either of them.

The total number of messages dealt with during the twenty days of active operations, in the twenty-six military telegraph offices that were established for purposes of the army and expeditionary force in Egypt, was, roughly speaking, about 5,000. A large proportion of those messages, of course, were transmitted once or twice, which entailed several transactions. In one or two offices the messages amounted to 150 and 200 a day during the busiest time.

In the headquarters telegraph office at Ismailia, the control of the lines (it may be called) ought to have been maintained; but when circuits are in a very precarious state, as was the case with those we used, a great many interruptions of every possible kind will occur, and sometimes the delay is such that it is very difficult for those who use the telegraph, and who do not understand its liabilities and conditions, to understand the why.

An interesting little incident occurred at about 6.0 a.m. in the headquarters office at Ismailia. I was sitting there, the sun was just rising, and the clerk asked me to come up to the instrument. I could not read by sound, and I asked him to interpret it for me. He said: "He says, sir, that the firing is so heavy that he cannot read by sound; he is going to put on his inker." So after a minute he called us up again, and I asked what he then said. "The firing is coming nearer." Later the message came: "A shell has just burst outside." And again: "Wait a minute; I will go and see what is going on;" and in about five minutes he called us up and gave an exciting account of the battle that was going on. It was an instance of realising at a distance what one could not see.

The *watching* of the traffic is a very important function in military lines. It is necessary, because, unlike the traffic of a country in time of peace, there are some messages of great importance—in fact, that are paramount. In other words, it is almost necessary to classify the messages. This cannot possibly be done by clerks who are trained to forward messages according to their code, and it requires somebody who not only has sufficient authority to give precedence, but who has sufficient judgment absolutely to enter into the mind of the sender, so as to do so in a judicious manner. It is an office which, I must say, I think

there are not many people capable of filling. You must know the wants of the army; you must know what is likely to be the greatest exigency of the moment, and you must guess at a good deal.

During the thirty hours following the battle of Tel-el-Kebir, the lines between Kassassin and Ismailia, as I have said, were congested with the amount of traffic, and the relative importance given to messages was ruled very much by what was known to be the real wants of those who wanted most. Now those who wanted and suffered most were the sick and wounded: of course all messages in connection with them got precedence of everything else. There were messages from the General of the very greatest importance; amongst others there were messages from the War Office and Admiralty, long cipher messages, of which there are specimens before you. I may say, without breaking their secrecy, that these cipher messages consist of groups of six figures, and of course we all know that one figure in a group wrong would make a very great difference in the message; and as far as I can learn but very few repetitions were necessary, and I believe on the whole they were telegraphed with very great accuracy. That accuracy was due to the excellent training which all our clerks have had in the Postal Telegraph Department, a service where they learn their work as it can be learned in no other country in the world. It was very hard to find oneself obliged to delay such messages as I have described earlier this evening, from friend to friend, making enquiries, and telling them that they were well and so forth; but you will quite understand that as long as the people were well I did not think there was much harm in delaying their messages.

In commencing the few words which I have had the honour to address to you to-night, I referred to the work of Col. Frank Bolton, and his visual signalling, because I wanted you to recollect that visual signalling is the handmaid to telegraphy, or should be so. It simply is another "means of communicating intelligence." The signalling of the army was under an officer whom I had the pleasure of serving with in the manœuvres of 1872 (Lieut.-Col. Keyser), and I do not know whether he recollects being present when the paper by me was read on the autumn manœuvres of that

year. I am glad to see him here this evening. Perhaps he recollects that at the end of that evening I was startled and astonished by finding everybody getting up and sympathising with me. Well, without knowing it, I criticised the work of which I had the direction (I did not criticise the workmen) rather sharply, as is generally my habit. I compared it with what it might have been had it been perfection, and to my astonishment several of my friends in the room rose and condoled with me on my failures. Well, now, this time I do not intend to raise any condolences with Colonel Keyser on his failures, because his failures were very, very few. The maintenance of a signal station in a desert and under a broiling sun is, I think, only worse than the maintenance of a telegraph office. Three or four men have to stand on a knoll during the greater part of the day, where they have to forward signals, either by flag or by heliograph, to another knoll, which may be distant or near, but which must be within sight. Between what we call the front, Kassassin, and Ismailia, there was a line of signal stations established, which supplemented the telegraph line, and these stations were almost coincident with the telegraph ones—not quite; at any rate the terminal one was coincident with our Headquarter office, in fact it was on the roof of Headquarters itself, whereas the telegraph office was in a tent in the garden; and very often the line of signallers brought down messages when we were seriously in want of assistance through faults on the telegraph line.

You can clearly understand that a signal station having no wire connecting it with its neighbour is a very much more simple thing than a telegraph line, and that its use is much more adapted to the moving parts of an army in the field and for short distances in camp than a field telegraph.

For this reason, and from my two African experiences, I foresee that signalling of a high order, and with specially trained men, will sooner or later do much of the work that the field telegraph is now put to.

I mentioned before that it was our duty to restore the telegraph lines and offices to the Egyptian Administration. This work was quickly done with all offices, except those at Cairo, by the 22nd

September. It is not necessary for me to more than mention that we worked and maintained several offices there after our arrival, as that was a mere peace operation. Nothing could be more cordial than the way in which we worked with the officers of the Egyptian Administration, with Mr. Floyer, Superintendents Greenwood, Clark, and M'Cullogh, and all the clerks. We gave them what assistance we could, and they rendered us all the information in their power. At first we had the advantage, because we had plenty of clerks. As the army advanced they brought their men to work again, and gradually took over their lines, but I rather think it will be some considerable time before those lines are all in their normal state. A considerable section of the line near Alexandria, the main line from Cairo to Alexandria, of eleven wires, was wrecked near Kafr-Dowar, and I saw other places which will give a good deal of trouble. During the fire at the terminus, Cairo, the large line which runs northward out of the station, consisting of twelve or fifteen wires, was destroyed for a great many spans by the falling on it of portions of a large burning house. Our Telegraph Corps did good service on that occasion: they repaired the line while a considerable amount of danger from the fire and from the bursting of shells and other things still existed. Not only did they repair it once, but as the house continued to fall they repaired it twice and three times, and that was all done with creditable speed during the hottest parts of the day.

I have already alluded to the idea of dividing telegraphs into various classifications, and, although it may be fruitless referring too often to it, I cannot resist hitting out once again at the error. I hope all here are agreed that it should mean a division which has nothing to do with the supervision or the *personnel*, but expresses the difference of materials used, and that will help me. There is a phrase in military diction which may do some harm to the telegraphs. Lately it has become prominent. I devoutly hope it may not. I mean the phrase, "line of communications." I think before the Franco-German war the expression, except as a military one, was hardly met with in English; now, it is one of those that is in everybody's mouth. Everything is "line of communications," and there is no doub

that "line of communication" is a very important matter. But there is no reason to my mind to believe that the "line of communications," so far as the telegraphs are concerned, is distinct from any other portion of the telegraphs of the army. The material that is used on the "line of communication" in telegraphs, depends entirely upon the existence or not of a telegraph in the country through which you are moving. The *working* of offices of "lines of communication" may require, and generally does so, exactly the same kind of clerk, message-form, and discipline, as in any office in the field; and therefore I hope that the phrase "line of communications" will never be imposed upon telegraphs, which should be as free as air of all classification, and of all empirical rules which are the outcome of, I do not say want of experience, but of not thinking, that in no two wars (that is our experience) in late years, have the telegraphs worked under like conditions.

If we have division of maintenance in our national telegraphs, it is under very much more favourable circumstances. It would be very much as if my friend Mr. Patey were to offer every encouragement he could to divided maintenance. I am quite certain he neutralises its evils, and reduces it to a minimum. It would be as if you lighted a town by electricity, and placed a station for producing in every house, instead of at several centres.

I hope I shall not be understood to say anything against "lines of communication," because, far from it, this year I launched out in a pamphlet on the subject, and will now read an extract from it, which was written when the Egyptian Expedition was not thought of.

"Now, successful wars are being conducted at railway speed, and campaigns that in former times required years now occupy months, so that everything which will conduce to the increase of that speed should be adopted, and amongst these the rapid and punctual working of the lines of communication, with the assistance of the enormous facility and opportunities for saving time and applying means to the best advantage, afforded, amongst other things, by the telegraph—a facility in aid of the traffic which can

easily be understood. But if the telegraph is a valuable auxiliary, it is also one requiring great judgment and experience in the use of it.

"It has been well said that the extension of railways on the scale we have witnessed in half a lifetime would have been absolutely impossible but for the telegraph."

"When the army learns to apply the telegraph as extensively to a line of communication as it is used by railway companies, commensurate results will be produced in war."

I am very sorry for having occupied the meeting this evening so long, but in a subject like this it is very difficult to select one's matter. I have brought with me a great number of interesting, harmless messages, some of which you would like to have heard, but the evening is so very late that I, as your President, am bound to maintain discipline, and the first way to do so is to be amenable to it oneself.

It is necessary indeed to apologise for occupying this evening at all. It is a thing most unusual in a President of a society to occupy two evenings during his period of office, for I had one at the beginning of the winter session. There are only two pleas—firstly, that your Council expressed a strong wish that I should endeavour to undertake to give you some idea of what was done in Egypt with telegraphs; secondly,—and as regards it I hope you will not consider there is any vanity to be laid to my charge,—that I believe it is not usual for the President of any of the scientific societies to spend his time during the recess in the active operations of a campaign.

Mr. W. H. PREECE, F.R.S., Chairman: Col. Webber took a great deal of pains to convince us that there was "no delusion" in the battery he has brought before us, and by doing so he conveyed the idea to some of our visitors that the Society of Telegraph Engineers was in the habit of deluding its visitors and its own self. But at any rate to-night Col. Webber has proved the reverse of that notion, by neither deluding nor deceiving us in the character of the paper that he has given us. We are all delighted to see him back safe and sound amongst us; and though we do not wish that there may be other wars for him to spend his time during the recess,

still we do hope that, if the telegraphic service of this country and the army itself shall ever be called upon to carry out a similar magnificent and splendid work to that which they have recently done, they may have at their beck and call an officer as able as Col. Webber to take charge of the telegraphs.

When I saw so many present interested in naval and military matters, I had hoped that to-night we might have had an interesting discussion, but Col. Webber has not left us much to discuss. The evening is so late that I will just ask the members present if they have any questions to ask Col. Webber, and then I will call upon two of our members to propose and second a vote of thanks to Col. Webber for his paper. Therefore, if any member has any questions to ask or observations to make, we shall all be very glad to hear him.

Mr. C. F. VARLEY: Col. Webber has made, no doubt in good faith, a statement that Col. Bolton was the first to occupy himself with military telegraphs in 1861. In April, 1854, or early in May, I submitted a plan for a telegraph which could be attached to a gun-carriage, and run out and picked up again with great speed. My friends to whom I showed the plans and description were so pleased with them that they asked me for my drawings and the description, and put them before Lord Raglan. As he was about to depart for the Crimea, he sent the documents to the late Prince Consort, who handed them to Gen. Wilde, one of the directors of the Electric and International Telegraph Company, with instructions from the War Office to equip and send out a staff of telegraphists to the Crimea. Volunteers were called for, and a well-selected staff was sent out, with all the necessary apparatus, Gen. Wilde having entrusted me with the task of superintending the preparations. The telegraphists went out under my brother, S. A. Varley, and were placed in the Crimea under the orders of Gen. Neale (I am not sure whether I have spelled his name correctly). They laid the telegraph from Balaclava to headquarters, and from headquarters to the trenches. The instruments used were the single-needle. As my brother and some of his staff were constantly under fire, they received the Sebastopol medal and the Balaclava clasp. This, I believe, was the first military

telegraph ever organised—organised under the auspices of the oldest, in fact the original, telegraph company of the world.

Mr. W. T. ANSELL: Mr. Chairman,—In rising to propose a vote of thanks to our gallant President for his very interesting paper, which I am sure will need no seconding, but will be carried by acclamation, I will second your remarks in congratulating him upon his return in safety amongst us; and I also congratulate him upon the public acknowledgment which has been bestowed upon him at the hands of Her Majesty, in recognition of his services in the field. There are one or two points which perhaps Col. Webber will permit me to correct him upon. I made a note on a matter of very little importance. The Eastern Telegraph Company's direct Suez wire does not go *via* Balbeis, but by the Benha junction.

The Eastern Telegraph Company's lines are not maintained by the Egyptian Government, but by the Eastern Telegraph Company itself.

With regard to the accuracy of the Admiralty telegrams, as signalled by the army signallers, I am quite sure that the meed of praise bestowed by Col. Webber is well deserved. But the majority of these Admiralty telegrams travelled from England before they reached the base of operations, if I may remind you, Colonel. And although they came so accurately over the military lines, they must have come with equal accuracy over the lines of the Eastern Telegraph Company; therefore I simply do justice to our own staff in mentioning that fact, and you will excuse my doing so.

Col. Webber has made an allusion to the importance of keeping open the "lines of communication." He spoke from a military, and from a soldier's point of view. In the operations in Egypt, of course the base was the Suez Canal, and Ismailia the headquarters. But there was a further base to the rear of the Suez Canal, and that was the headquarters in England. The communication was kept up in the first place entirely by the submarine cable, and but for the forethought of my directors, which enabled them at a moment's notice, I may say, to lay a cable from Alexandria to Port Said, Sir Garnet Wolseley would have found himself a long

way off from his headquarters base. It may be of interest if I explain how that came about. When the events of the 11th June startled everybody, it was clearly seen that we were on the eve of some very great events. The Eastern Telegraph Company had one of their ships in the Indian Ocean: she had to come into Aden for stores and coals. My directors immediately ordered her up to Suez, and to make her way through the Canal if she could get through. It was felt a very touch-and-go matter then as it was doubtful whether the Egyptians would stop the passage of the Canal. However, they did not do so, and the "Chiltern" got through, and made the best of her way to Alexandria. There she was converted into a floating station, and until long after the bombardment the whole of the staff of the Eastern Company were located on board that vessel, did all the work, and kept open the "line of communication."

The cable which was laid from Alexandria to Port Said came about in this way. It was only a day or two before the general commanding-in-chief left England that he intimated the desirability of laying cable communication between Port Said and Alexandria. The Eastern Telegraph Company happened to have a cable ship, the "John Pender," engaged upon some works on the coast of Portugal, and she made the best of her way, according to her orders, to Alexandria, and she was fortunate enough to be able to lay that cable from Alexandria to Port Said almost within a day or two from the time when the use of it was required by the general commanding-in-chief. These are interesting incidents which I thought it reasonable to mention, as supplementary to the very interesting paper which Col. Webber has given us. I need not repeat the proposal which I made at the beginning of my remarks.

Mr. C. H. B. Patey: Gentlemen,—I have very great pleasure in seconding the vote of thanks to the President, Col. Webber, which has been proposed by Mr. Ansell, for the interesting lecture we have listened to to-night. As a fellow-officer in the Post Office with Col. Webber for many years, it is with very great pleasure that I, and I am sure I may add those other officers of the Post Office who are here to-night, have heard the praise with which he

has spoken of the work and behaviour of the Royal Engineers employed in Egypt. A large number of Post Office officials were sent out for purely postal business; and at the same time, although it was known that the Royal Engineers would be chosen, a large number of applications were made by persons in the service to be allowed to volunteer for telegraph service in Egypt, and I am sure that we should have had no difficulty in finding as many men as those who went on purely postal work who would have willingly gone out. Indeed, it was a great disappointment to a large number of men that they were not allowed to go. Several Royal Engineers will return within a few days to the offices from whence they were drawn, and I am certain that they will meet with a welcome in spite of a little heartburning on the part of their fellow-clerks who were left at home.

We are glad to hear that the training the Post Office has been able to give to the Royal Engineers has turned out so well; and although, when they came into the department some years ago, there was considerable difference of opinion, we are delighted to find that in this, as in a previous war, they have done their duty well, and have brought credit to the department.

I have very great pleasure in seconding the vote of thanks to Col. Webber.

Mr. W. H. PREECE, as Chairman, put the vote to the meeting, which was carried in a most cordial manner.

Lieut.-Col. WEBBER, R.E. (President), in reply, said: Mr. Preece and gentlemen,—I thank Mr. Ansell very warmly for his supplementary remarks to what I said. I also have to thank Mr. Patey for the words which he used in seconding the vote of thanks to me. I saw a great deal of the Post Office Corps which went out, and I recollect that regiment very well when they were the 49th Middlesex. They are very old friends of mine, and whenever I had a chance it was always with the greatest pleasure that I encountered them. I could do very little for them, for really I was one of those people who had only the clothes I stood in, and therefore my powers of hospitality were limited, but as regards good-will and admiration for their work, I now take the opportunity of giving the most cordial evidence. It often struck me while they were out

that their coming to the army—and I myself was on the committee some years ago, which was formed on Sir Garnet Wolseley's suggestion, which drew up the rules under which they came out—was only a step towards a large body of the 49th Middlesex going with the Army Telegraphs.

This evening, just before coming to this meeting, I received a letter from a distinguished officer who had a card of invitation to attend, and one thing he said in the letter was that he hoped that the outcome of the discussion to-night would be an expression of opinion that, instead of having 50 or 60 clerks, we should have had 200. Well, I see no way better of accomplishing that at present with our limited military establishment, to meet the wants of any great war that we may undertake, except by the very means mentioned by Mr. Patey.

The meeting then adjourned until the Annual Meeting on December 14th next.

The Eleventh Annual General Meeting of the Society was held on Thursday evening, 14th December, 1882, at the Institution of Civil Engineers, 25, Great George Street, Westminster—Lieut.-Col. C. E. WEBBER, R.E., C.B., President, in the Chair.

The PRESIDENT apologised for the late arrival of the Council, and said that the business of the Society increased so rapidly that it was only possible to get through it by extending the deliberations and sittings of the Council. That evening they had had before them a question of the greatest importance, and their anxiety to close the subject that evening compelled their being a quarter of an hour late in coming before the general body of the Society, although they had been called together a quarter of an hour earlier than usual.

The minutes of the last meeting were read and confirmed.

The PRESIDENT announced that the ballot box for the new Members of Council and Officers for the forthcoming year would be open until half-past eight o'clock, for the reception of voting papers, and Dr. W. H. Stone and Mr. J. Munro were appointed scrutineers of the ballot.

The SECRETARY then read the following reports:—

REPORT OF THE COUNCIL TO THE ANNUAL GENERAL MEETING OF THE SOCIETY.

DECEMBER, 1882.

The Council have the satisfaction of reporting that the several classes of members have been increased during the year as follows:—

Foreign Members	9
Members	10
Associates	74
Students	7
Total	100

In addition to these, 5 candidates have been announced for ballot this evening, and 39 for ballot next month.

On the other hand, the Society has lost by deaths and resignations, 5 Foreign Members, 10 Members, and 17 Associates.

Among the deaths, we have specially to lament the loss of General Von Lüders, Foreign Member, and Captain Gill, R.E., Mr. C. Hockin, Mr. J. C. Laws, and Mr. Louis Schwendler, Members.

It is again the pleasing duty of the Council to record the continued liberality of the Institution of Civil Engineers, in permitting the Society to hold its meetings in their capacious and beautifully decorated Lecture Hall.

During the year, the following papers, embracing a variety of both scientific and practical subjects, have been read. Among the former, Mr. Stroh's description of his beautiful experiments on Attraction and Repulsion due to Sonorous Vibrations created so much interest, that by general request a repetition of the experiments was given by him at a subsequent meeting :—

PAPERS READ DURING THE SESSION 1882.

	SUBJECT.	AUTHOR.
Feb. 9.	—The Pilsen Electric Arc Lamp...	H. F. Joel.
„ 23.	—On Siemens' System of Railway Gong Signalling	R. Von Fischer Treuenfeld.
Mar. 9.	—On Measurement in the Medical Application of Electricity ...	Dr. W. H. Stone, M.A., and Dr. W. J. Kilner.
„ 23.	—On the Development of a New Telephonic System	Prof. A. E. Dolbear.
April 13.	—Description of a Form of Battery of Low Internal Resistance ...	F. Higgins.
„ 13.	—Tests of Incandescent Lamps for Fall of Resistance with Increase of Electro-motive Force and Ratio of Candle-power to work done on Lamp	A. Jamieson.
„ 27.	—On Attraction and Repulsion due to Sonorous Vibrations, and a Comparison of the Phenomena with those of Magnetism ...	A. Stroh.
May 11.	—On Measuring-Instruments used in Electric Lighting and Transmission of Power	Profs. W. E. Ayrton, F.R.S., and John Perry, M.E.
„ 18.	—Repetition of Mr. Stroh's Experiments.	

SUBJECT.	AUTHOR.
May 25.—On a New Method of Determining Large Electric Currents and very Low Resistances	Lieut. P. CARDEW, R.E.
„ 25.—On the Organisation and Operations of the Field Telegraph Corps in the Transvaal, 1881, with some General Remarks on Field Telegraphs...	Lieut. A. H. BAGNOLD, R.E.
July 11.—On Submarine Mining	Major R. Y. ARMSTRONG, R.E.
Nov. 9.—The Munich Electrical Exhibition, 1882...	W. H. PREECE, F.R.S.
„ 23.—Notes on the Telegraphs used during the Operations of the Expeditionary Force in Egypt...	Lt.-Col. C. E. WEBBER, R.E., C.B.

In addition to these, many valuable original communications have been published in the Journal, together with a selection of extracts from contemporaneous scientific publications.

A general index to the first ten volumes of the Journal, carefully compiled by our Librarian, Mr. Alfred J. Frost, has proved of great value and convenience.

In the month of July last, Lieut.-Colonel C. E. Webber, R.E., C.B., as President of the Society, held, by permission of the Military authorities at Chatham, a reception at the Brompton Barracks, and a large number of members and distinguished visitors were afforded the opportunity of witnessing various operations and experiments connected with every branch of military engineering, and the preparation of much of the war material and equipment destined for the then approaching Egyptian campaign, in which the President himself had subsequently the satisfaction of taking an important part as Staff Officer for Telegraphs. A detailed account of this very agreeable and successful visit to Chatham will be found in the Society's Journal.

In last year's Report, the International Exhibition of Electricity and the Congrès of Electricians at Paris naturally formed an important topic. That Exhibition was shortly afterwards followed by one at the Crystal Palace, and quite recently by one at Munich, where a carefully organised series of electro-technical experiments have been carried out, the importance and value of which is assured by the professional reputation of those conducting them.

A second Exhibition of Electric Light, in competition with Gas, was opened yesterday at the Crystal Palace, and an Exhibition of Electrical Appliances will shortly be opened at the Royal Aquarium, Westminster, circumstances testifying to the public interest now taken in the practical application of electricity.

During the past year a very large amount of capital has been subscribed by the public to companies established to work the various systems of Electric Light; and, whatever the commercial results of these undertakings may be, the expenditure of such a vast amount of money on this useful application of electricity cannot fail to be productive of important additions to our practical experience in this branch of electrical science.

An International Conference was held in Paris in November last, with the view of preparing a Convention for the protection of submarine cables. The delegates, 32 in number, agreed to certain recommendations on this important subject, which will have to be submitted by them to their respective Governments, and it is to be hoped that their labours will result in some satisfactory solution of a matter which not only deeply concerns those who have invested a vast amount of capital in submarine cables, but which affects the interests and the convenience of the whole civilised world.

During the same period another Conference also met at Paris, for the determination of the electrical units, and to consider certain questions relating to earth currents and lightning protectors. Important progress was made in its deliberations, but the final resolutions will not be arrived at until an adjourned meeting to be held in October of next year.

The already large and still increasing use of the Electric Light has naturally attracted the attention of the Fire Insurance Companies, who, in the absence of technical knowledge of the subject, were feeling considerable embarrassment in dealing with the insurance of buildings in which the light was installed; and the Council considered that it would be a public advantage that a series of rules should be drawn up for the guidance and instruction of those who have, or intend to have, the electric light installed in their

premises, with the view of reducing to a minimum the risks of fire arising therefrom.

They accordingly appointed a Committee to consider the subject, and report thereon.

The Committee had the advantage of several interviews with the Chairman and Secretary of the Fire Offices Committee, which represents the principal Fire Insurance Companies, and, as the result of their deliberations, have drawn up the rules which were adopted by the Council, and which were published in Part 43 of the Society's Journal, and also in a separate pamphlet form. The Council have reason to believe that the rules have been adopted by all the principal Fire Insurance Companies in the United Kingdom, as well as by the Electric Light Companies.

In 1879, Mr. J. J. Fahie, Member, very liberally presented to the Society a sum of £100 towards the formation of a fund for providing premiums to be awarded for papers read before the Society.

This year the British Exhibitors at the Paris International Electrical Exhibition decided to present to the Society, for a similar purpose, as a mark of their appreciation of the services rendered by it in their behalf, a sum of £110 5s. 3d., being the surplus balance of their guarantee fund, and the Council considered that the time had arrived, therefore, when the Society should out of its own funds supplement these handsome donations, and they decided on offering, as was announced in May last, three annual premiums, viz.:—

1. The Society's Premium, value £10.
2. The Paris Electrical Exhibition Premium, value £5.
3. The Fahie Premium, value £5.

They trust that the institution of these annual premiums will stimulate the younger members to send in papers worthy of the many subjects embraced in electrical science and its applications.

The Society continues to benefit by the kind services of the several local honorary secretaries and treasurers, who, at no little personal trouble, not only collect and remit the subscriptions of the members attached to their respective secretariats, and in some instances distribute the Journal to them, but continually obtain fresh recruits for the ranks of the Society.

Your Honorary Solicitor has made the necessary application to the Board of Trade for the incorporation of the Society under the Joint Stock Companies Acts.

The Council hoped that the Memorandum and Articles of Association would have been ready to submit to a meeting of members this evening, but it was found that some points still required the consideration of the Solicitor, and a special meeting will be convened shortly to deal with the matter.

The Council are glad to be able to report that the finances of the Society are in a satisfactory condition. During the present year the whole of the life compositions received since the establishment of the Society, amounting to £741, will have been invested in Colonial or Government securities.

By order of the Council,

14th December, 1882.

F. H. WEBB,
Secretary.

6, WESTMINSTER CHAMBERS,
VICTORIA STREET, LONDON,
13th December, 1882.

F. H. WEBB, Esq.,
Secretary,
The Society of Telegraph Engineers and of Electricians.

DEAR SIR,

I have the honour to submit, for the information of the Council, my Third Annual Report upon the Library of the Society.

I have great satisfaction in stating that the visitors to the Library during the present year have been, as will be seen from the figures given below, more numerous than the preceding year, although the facilities offered for the use of the Library in the evening have not been taken advantage of, by either the members or the general public, to the extent that was originally anticipated. The number of persons who signed the visitors' book are as follows:—

Members	313
Non-members	248
Total	561

—being 133 members and 90 non-members in excess of the numbers given in my last report. As all the visitors do not sign the visitors' book, the actual number of persons who used the Library during the year amount probably to about 600.

The specifications of electrical patents have been much referred to during the year, and to a greater extent than the other works in the Library, the periodicals alone excepted. It has been found of especial value to those using the Library to be able to refer to all the current patents relating to our subjects, immediately they are published, and without the necessity of a journey to the Patent Office, and the trouble of searching out the electrical patents; and the thanks of the Society are due to Mr. R. Morris, the Superintendent of the Store Department, for the prompt manner in which he has complied with my requirements, and thus enabled me to produce this result.

The extent of the accessions to the Library will be seen from the catalogue appended to this report. The number of works presented and purchased amount to 245, being 80 more than those acquired in the previous year. The greater part of these books and papers have been presented to the Library, the names of donors having been reported from time to time at the meetings of the Society. As this list of additions to the Library is already too lengthy to be of practical service to the members, when issued in this form, I have decided in the future to report them in full at each meeting of the Society, in order that the titles may be printed in the current numbers of the Journal.

Many members of the Society have expressed their desire that the Library should possess a few standard works upon Physical Science not treating of electricity and magnetism only, and although I am of opinion that the usefulness of the Library would be much enhanced by such additions, I have not, up to the present time, been able to act upon their suggestions; but the matter is under the consideration of the Library Committee, and I hope to be able to report a few of such accessions during the next year. Perhaps, when it is known that these works are required, the known liberality of the members of the Society will enable me to place a few of them upon the shelves, without intrenching upon the funds

already too limited for the proper completion of our magnificent collection.

During the discussion on the Annual Report last year, Mr. H. R. Kempe remarked that it would be a great advantage to the electrical world if the Library possessed a classified catalogue of the Patent Specifications relating to Electricity and Magnetism, and Colonel Bolton, in his paper lately read before the Society, also referred to the same subject. There can be no doubt that some arrangement for facilitating reference to the patent specifications is very much required, but it would be inexpedient to bind up the specifications in classified order, as suggested by Colonel Bolton, owing to the difficulty there would be in finding any particular patent, when the year and number of the patent only are known; and the difficulty could only be met by the compilation of a classified index.

The Catalogue of the Library, as it at present exists, is simply an author catalogue, and consequently of little practical value unless the name of the author of the work is known; and when it is considered that, irrespective of periodicals and patent specifications, the number of separate works and papers in the Library extend to over 13,000, it will be seen that some difficulty is experienced in meeting the requirements of those using the Library who are not acquainted with the names of the authors of the works they wish to refer to. A classified catalogue of electrical literature is a want that has long been felt, and, although I see no prospect of such a work being at present carried out, I feel it my duty to call the attention of the Council to the question. I am constantly receiving enquiries for lists of works relating to special branches of our subjects, and it is exceedingly difficult, and in many cases impossible, to make such lists from memory when the works in the Library are so numerous. I shall take an early opportunity of bringing the matter before the Library Committee, and trust that at no far distant date the Library of the Society may be made still more valuable to its members by the addition of such aids to research as those I have referred to, and which are now considered, in every well regulated library of any importance, to be absolutely necessary.

In September last, as the representative of the Society, I attended the Annual Conference of Librarians (this year held at Cambridge), and I was for the third time elected a Member of the Council of the Library Association of the United Kingdom.

In conclusion, I would remark that the thanks of the Society are due to those members and others who have voluntarily, and at my request, presented the Library with copies of their works; and as it is so important that every printed document bearing on our subjects (whether treatises, reports, or other works) should be preserved in the Library for future reference, the perfection of our collection must always more or less depend upon the co-operation of the members of the Society.

I am,

Faithfully yours,

A. J. FROST,

Librarian.

LIST OF ACCESSIONS TO THE LIBRARY DURING THE YEAR 1882.

By Alfred J. Frost, Librarian.

(*Works marked thus * have been purchased.*)

* **Abernethy** [J. P.] An Outline of Commercial and Railway Telegraphy in Theory and in Practice, arranged in questions and answers. 8vo. 112 pp. *Cleveland*, 1882

* **Akenside** [M.] The Pleasures of Imagination. [Poem.] 8vo. 401 pp. [*See* page 88.] *London*, 1778

* **Algave et Boulard.** La Lumière électrique, son histoire, sa production, et son emploi, etc. 8vo. 464 pp. *Paris*, 1881

Allgemeiner Deutscher Telegraph. 2 vols. 4to. *Stuttgart*, 1857-58

Ampère. [*Vide* Neumann, Dr.]

Ampère e Simon. Correnti elettriche prodotte per influenza di un' altra corrente. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1832

* **Annales Télégraphiques.** Vols. III. and VI. *Paris*, 1876, 1879

* **Anon** [J. E. K.] The Telephone in Principle and Practice; its Origin and Development. 8vo. 89 pp. *London*, 1882

——— [M. * * *] Lettre sur l'électricité. 8vo. pp. 44 to 52. [*Mercure de France, Février*, 1746.] 1746

——— Théorie mécanique de l'électricité et de l'aimant. 8vo. 16 pp. [A Fragment.]

* ——— Les différents systèmes de téléphones et leur application. 4to. 19 pp. Plates. *Paris*, 1882

Antinori. [*Vide* Nobili e Antinori.]

Armengaud Jeune. Réunion Internationale des Electriciens. Paris Exhibition, 1881. 8vo. 328 pp. *Paris*, 1882

* "**Artizan,**" The. 8 vols. 4to. 1858 to 1865. *London*, 1858-65

* **Augustinus** [A.] De Civitate dei. Fol. [*See* p. 718.] *Basileæ*, 1522

* **Bakewell** [F. C.] Electric Science: its History, Phenomena, and Applications. 8vo. 199 pp. *London*, 1853

Ball [R. S.] Experimental Mechanics. Large 8vo. 352 pp. *London and New York*, 1871
[Presented by Messrs. Macmillan & Co.]

* **Bardet** [Dr. G.] De l'Exposition d'électricité. 8vo. 65 pp. *Paris*, 1882

Barlow [Peter]. An Essay on Magnetic Attractions, particularly as respects the Deviation of the Compass on Shipboard. 8vo. 145 pp. Plates. *London*, 1820
[Presented by Col. Bolton.]

Barus. [*Vide* Strouhal u Barus.]

Beard [Dr. G. M.] The Study of Trance, Muscle Reading, and Allied Nervous Phenomena. 8vo. 40 pp. *New York*, 1882

Becquerel [M.] Mémoire sur l'électro-chimie et l'emploi de l'électricité pour opére des combinaisons. 8vo. 40 pp. [Lu à l'Académie des Sciences le 23 Février, 1829.] [*Ext. des Ann. de Chimie et de Physique*, 1829.] *Paris*, 1829

Belli [G.] Di un nuova maniera di machina elettrica immaginata. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto*, pp. 111 to 123.] *Padova.*

* **Bergmann** [Torbern]. A Dissertation on Elective Attractions. Translated from the Latin. 8vo. 383 pp. *London*, 1784

Berly [J. A.] British and Continental Electrical Directory and Advertiser. 8vo. 233 pp. *London*, 1882

* **Bonnefoy** [Dr. E.] Guide practique d'Electrothérapie du Dr. Onimus. 8vo. 343 pp. *Paris*, 1882

—— [J. B.] Analyse raisonée des rapports des commissaires chargés par le Roi de l'examen du magnétisme animal. 8vo. 89 pp. 1784

Borns [G. M.] Tables of Metric Measures and their English Equivalents. 8vo. 33 pp. *London*, 1879

Bouchardat. Relazoni fra le azioni elettriche e le azioni chimiche. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1834

Boulard. [*Vide* Alglave et Boulard.]

* **Bower** [Geo. S.] and **Webb** [Walter]. The law relating to electric lighting; being the Electric Lighting Act, 1882, &c. 8vo. 259 pp. *London*, 1882

Brooks [David]. Facts and Inferences relating to Lightning and Lightning Rods. 8vo. 16 pp. *Philadelphia*, 1872

—— Atmospheric Electricity. 8vo. 14 pp. *Philadelphia*, 1878

Burnett [W. H.] The Electric Telegraph. 8vo. 24 pp. *London*, 1862

* **Bury** [Rt. Hon. Viscount]. Electric Light and Force. 8vo. 22 pp. [*Nineteenth Century, No.* 65, *July*, 1882.] *London*, 1882

* **Campbell** [Lewis] and **Garnett** [William]. The life of James Clerk Maxwell, with a selection from his correspondence and occasional writings, and a sketch of his contributions to science. 8vo. 662 pp. *London*, 1882

Cape Telegraphs. Reports for 1877, 1878, 1879, 1880. Fol. *Cape Town*, 1877-80

Cardarelli [F.] Rappresentazione Grafica dilla resistenza dei circuiti derivati. 8vo. 15 pp. *Roma*, 1881
[Presented by Prof. Hughes.]

* **Caustic** [Christopher] M.D., LL.D., A.S.S. Terrible Tractoration!! A Poetical Petition against Galvanising Trumpery and the Perkinistic Institution. 8vo. 186 pp. *London*, 1803

Cew. [*Vide* Glaser-de Cew.]

* **Charleton** [Walter].
A Ternary of Paradoxes.
The { Magnetick Cure of Wounds.
Nativity of Tartar in Wine.
Image of God in Man. }
Written originally by J. B. Van Helmont. 8vo. 144 pp. *London*, 1650

Chavannes [Roger]. Theorie élémentaire des machines magnéto et dynamo électriques. 8vo. 28 pp. Tables. *Lausanne*, 1881

* **Christiani** [Arthur]. Beiträge zur Electricitätslehre über irreciproke Leitung electrischer Ströme nebst einem Excurse des Potentials zweier Spiralen. 8vo. 174 pp. Plates. *Berlin*, 1878

Clark [Latimer]. A Treatise on the Transit Instrument as applied to the Determination of Time. 72 pp. Transit Tables for 1882. 8vo. 29 pp. *London*, 1882

Clark, Muirhead, & Co. [*Vide* Liveing.]

* **Classen** [Dr. A.] Quantitative Analyse auf electrolytischem Wege. 8vo. 52 pp. *Aachen*, 1882

Collet [A.] Traité Théorique et pratique de la régulation et de la compensation des compas avec ou sans relévements compas compensé de Sir Wm. Thomson et appareils auxiliares compas compensé et compas correcteur de M. J. Peichl. La 8vo. 295 pp. *Paris*, 1882

Colson [Jno.] M.A. [*Vide* Musschenbroek, P. Van.]

Common [A. A.] Particulars of the Mounting of a Three-foot Reflector. 4to. 11 pp. Plates. [Reprinted from *Memoirs of the Royal Astronomical Society, Vol. XLVI.*] *London*, 1879

Conference, Lightning Rod, Report of the. Edited by G. J. Symons, F.R.S. 8vo. 261 pp. *London and New York*, 1882

Congrés International des Electriciens. Comptes Rendus des Travaux. Royal 8vo. 400 pp. *Paris*, 1882

Cooke [Conrad] **and others.** Electric Illumination. Chiefly compiled from *Engineering*. Edited by James Dredge. With Abstracts of Specifications having Reference to Electric Lighting, prepared by W. Lloyd Wise. Vol. I. 4to. 693 + cxc. pp. *London*, 1882
[Presented by Conrad Cooke, Member.]

Cossmann [M.] Etude sur la concentration et l'enclenchement des leviers des aiguilles et signaux manœuvrés a distance. Large 4to. 77 pp. Plates. [*Ext. de la Revue Générale des Chemins de Fer. Juillet*, 1880.] *Paris*, 1880
[Presented by J. Aylmer, Local Hon. Sec

Crompton [R. E.] On Crompton's System of Electric Lighting. 4to. 30 pp. [*Engineering, Aug.* 26, 1881, and other papers.] *London*, 1881

Crookes [Wm.] [*Vide* Faraday, M.]

* **Culley** [R. S.] A Handbook of Practical Telegraphy. 8vo. 426 pp. 7th edn. *London*, 1878

Cumming [Linnæus] M.A. An Introduction to the Theory of Electricity, with numerous Examples. 8vo. 308 pp. 2nd edn. *London*, 1879 [Presented by Messrs. Macmillan & Co.]

* **Day** [R. E.] Exercises in electrical and magnetic measurement, with answers. 12mo. 120 pp. *London*, 1876

* ——— Electric Light Arithmetic. 12mo. 80 pp. *London*, 1882

Day [St. John V.] Report on Motors (Air and Gas Engines) Tested at the Exhibition held in Glasgow, September and October, 1880. 8vo. 11 pp. *Glasgow*, 1882

Delarge [F.] Notes sur l'électricité dynamique. 8vo. 78 pp. *Bruxelles*, 1882

Delaurier [M.] Notice analytique des inventions de M. Delaurier a l'Exposition Internationale d'électricité, Paris. 8vo. 20 pp. *Paris*, 1881

* **Denza** [P. Francesco.] Variazioni della declinazione magnetica. 8vo. 24 pp. *Torino*, 1879

Douthwaite [W.] Catalogue of Books in the Library of the Hon. Society of Gray's Inn, with an Index of Subjects. Large 8vo. 279 pp. *London*, 1872

——— Supplement to Catalogue of Books in the Library of the Hon. Society of Gray's Inn, containing the additions thereto from March, 1872, to January, 1878, with an Index of Subjects. Large 8vo. 144 pp. *London*, 1878

Doyle [J. D.] Modern Forms of the Telephone. 8vo. 7 pp. *Melbourne*, 1882

Draper. [*Vide* Higgins e Draper.]

Dredge [James]. [*Vide* Cooke and others.]

Du Moncel [Le Comte Th.] Le Téléphone. Quatrième edn. 8vo. 390 pp. *Paris*, 1882 [Presented by J. Aylmer.]

* **Duter** [E.] Cours d'électricité. 8vo. 265 pp. *Paris*, 1882

* **Edelmann** [Dr. M. Th.] Die erdmagnetischen Apparate der Polar expeditionen im Jahre, 1883. 8vo. 34 pp. Plates. *Braunschweig*, 1882

* **Edinburgh Philosophical Journal.** 53 vols. 8vo. *Edinburgh*, 1819-45

* **Edlund** [E.] Untersuchung über die Wärmeerscheinungen in der Galvanischen Säule und über die elektromotorischen Kräfte. 8vo. 37 pp. [*Poggendorff's Annalen der Physik und Chemie.*] *Leipzig*, 1876 [?]

* **Electrician, The.** Monthly. *New York*, 1882

Ellis [W.] Longitude by Telegraph. 8vo. 7 pp. *London*, 1882

* **Euler** [L.] Letters on Natural Philosophy to a German Princess. 2 vols. 8vo. *Edinburgh*, 182

Everett [J. D.] D.C.L., F.R.S. Units and Physical Constants. 8vo. 175 pp. *London*, 1879
[Presented by Messrs. Macmillan & Co.]

Evrard [M. F.] Notice sur l'emploi des poteaux metalliques dans les lignes telegraphiques. 8vo. 46 pp. *Bruxelles*, 1877

* **Exley** [Thos.] Principles of Natural Philosophy. 8vo. 472 pp. *London*, 1829

Exposition Internationale d'Electricité. L'Electricité et ses applications. Large 8vo. 174 pp. *Paris*, 1881

——— Projet de Programme pour les séances du Congrés International, preparé par la Commission désignée par les membres français dans la séance du 1er Aout, 1881. Fcap. 4to. 8 pp. *Paris*, 1881

Faraday [M.] Svilluppo delle correnti magneto-elettriche per influenza del magnetismo terrestre. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1832

——— Sopra la conducibilità elettrica. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1834

——— Della influenza per induzione correnti elettrica. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1836

* ——— A Course of Six Lectures on the Various Forces of Matter and their relations to each other. Edited by W. Crookes, F.C.S. 8vo. 179 pp. *London and Glasgow*, 1860

* **Fechner** [T.] Repertorium der Experimental-Physik. 3 vols. 8vo. *Leipzig*, 1832

* **Ferrini** [R.] **e Pogliaghi** [P.] La Luminosità Elettrica dei Gas e la materia Radiante. 8vo. 315 pp. [*Biblioteca Scientifica Internationale, Vol. XXXII.*] *Milano*, 1882

* **Forciere** [Pietro]. La Telegrafia elettro-tecnia. 8vo. 264 pp. [The title page is dated 1883.] *Torino*, 1882

* **Frome** [C.] Ueber die elektromotorische kraft der aus Zink, Schwefelsäure und Platin resp. Kupfer, Silber, Gold und Kohle gebildeten galvanischen Combinationen. 8vo. 51 pp. [*Bes. Abdruck aus a XX. Ber der Oberh. Gesellsch-f-Natur-u-Heilkunde.*] *Giessen*, [?] 1880

Frost [A. J.] Index to the Journal of the Society of Telegraph Engineers and of Electricians. Vols. I. to X., 1872-82. 8vo. 63 pp. *London*, 1882

Fusinieri [A.] Delle scosse che provano gli animali exx circolo elettrico di Volta. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1831

Galletti [B.] **et Jounin** [A.] De l'électricité en général et de ses applications. Première partie. 8vo. 31 pp. *Paris*, 1844

Gamble [J.] A.M. An Essay on the Different Modes of Communication by Signals; containing an History of the Progressive Improvements in this Art from the first Account of Beacons to the most approved Methods of Telegraphic Correspondence. 4to. 122 pp. Plates. *London*, 1797
[Presented by Exchange.]

* **Gariel** [C.M.] Traité pratique d'Électricité, comprenant les applications aux sciences et à l'industrie, etc. 8vo. 203 pp. *Paris*, 1882

Garnett [Wm.] [*Vide* Campbell and Garnett.]

Gibb [Thos. E.] Report to the Lighting Committee of the Vestry of the Parish of St. Pancras on the subject of Electric Lighting with special reference to the Electric Lighting Act, 1882. Fo. 10 pp. *London*, 1882

Glaser-de Cew [G.] Die magneto-elektrischen und dynamo-elektrischen Maschinen und die sogenannten Secundar-Batterien. 8vo. 263 pp. Dated 1883. *Wien*, 1882

Goppelsroeder. Sur la formation des matières colorantes par voie électro-chimique. 8vo. 24 pp. *Paris*, 1881
[Presented by Prof. Hughes.]

Gore [G.] LL.D., F.R.S. On some Effects of transmitting Electric Currents through Magnetised Electrolytes. 8vo. 4 pp. [*Proc. Roy. Soc., No.* 217, 1881, *p.* 151.] [Abstract.] *London*, 1881

——— On the Electrolytic Diffusion of Liquids. 8vo. 3 pp. [*Proc. Roy. Soc., No.* 217.] *London*, 1881

——— The Scientific Basis of National Progress, including that of Morality. 8vo. 218 pp. *London*, 1882

* **Grawinkel** [C.] Die Allgemeinen Fernsprech-Einrichtungen der Deutschen Reichs-Post-und Telegraphen-Verwaltung. 8vo. 133 pp. *Berlin*, 1882

Gray's Inn. [*Vide* Douthwaite, W.R.]

——— [*Vide* Horwood, A. J.]

* **Grinwis** [Dr. C. H. C.] Wiskundige theorie der wrijvings electriciteit. 8vo. 266 pp. *Utrecht*, 1869

Grist [W.] Editor. Official Catalogue of International Electric Exhibition at Crystal Palace. 8vo. 108 pp. *London*, 1882

——— Locomotion, Non-Electric and Electric. 8vo. 16 pp. *London*, 1882

Grotrian [O.] Die Reibungsconstanten einiger Salzlösungen und ihre Beziehungen zum galvanischen Leitungsvermögen. 8vo. 36 pp. [*Ann. der Physik und Chemie.*] *Leipzig*, 1875

Grotrian. [*Vide* Kohlrausch and Grotrian.]

Guericke [Otto v.] Experimenta Nova (ut vocantur) Magdeburgica. Reprint. Fol. pp. 147-153 and xxi. *London*, 1881
[Presented by Prof. Hughes.]

Haldat. Sopra la incoercibilità del fluido magnetico. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1833

* **Hale** [Sir Matthew]. Magnetismus Magnus; or, Metaphysical and Divine Contemplations on the Magnet or Loadstone. 8vo. 159 pp. *London*, 1694

* **Hallez** [C.] Traité elementaire d'électricité. 8vo. 398 pp. *Paris*, 1882

Halske. [*Vide* Siemens and Halske.]

——— [*Vide* Zetzsche.]

* **Hankel** [W. G.] Elektrische Untersuchungen. 5 Parts. Large 8vo. *Leipzig*, 1875 to 1881

Haywood [Wm.] Report to the Streets Committee of the Hon. the Commissioners of Sewers of the City of London on the Results of the Electric Lighting of Public Ways within the City of London, 1881-82. 8vo. 67 pp. Map. *London*, 1882

Haywood [Wm.] Report of the Streets Committee to the Hon. the Commissioners of Sewers of the City of London on their Proceedings relative to the Applications for an Extension of the Experiments in Electric Lighting, with Abstract of Tenders prepared by the Engineer. 8vo. 23 pp. Map. *London*, 1882

Hazen [W. B.] Signal Service Army of the United States, and Special Catalogue of the U.S. Signal Service Exhibit at the International Exhibition of Electricity, Paris. 8vo. 43 pp. *U.S. America*, 1881

Hedges [Killingworth]. Useful Information on Electric Lighting. Crown 8vo. 156 pp. 3rd edn. *London and New York*, 1882

Hefner v. Alteneck [F.] Nebenlampe (Deviator) von Siemens und Halske. Large 8vo. 3 pp. *Berlin*, 1879

Helmont [J. B. Van.] [*Vide* Charleton, W.]

* **Heyenga** [Capt. H.] Neue Methode zur erleichterung der Bestimmung des Schiffsortes, der Variation und Devation des Compasses. 4to. 64 pp. *Hamburg*, 1882

Higgins e Draper. Circa le decomposizioni operate della elettricità di Volta. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1834

Highton [E.] [*Vide* Society of Arts.]

* **Hobbes** [Thos.] Dialogues of Natural Philosophy. 8vo. 136 pp. *London*, 1678

Hoffman [E.] Die Telegraphie und Electro-Technik, etc. Large 8vo. 19 pp. *Berlin*, 1879

Horwood [Alfred J.] A Catalogue of the Ancient Manuscripts belonging to the Hon. Society of Gray's Inn. Large 8vo. 22 pp. *London*, 1869

Hoskiœr [Col. V.] Guide des Épreuves Électriques a faire sur les cables télégraphiques. 8vo. 88 pp. Traduit sur la seconde edition anglaise, par A. L. Ternant. *Paris*, 1882

* **Hospitalier** [E.] Modern Applications of Electricity. Translated from the French, by J. Maier. 8vo. 456 pp. *London*, 1882

* **Humphreys** [J. D.] The Electro-Physiology of Man. 8vo. 228 pp. *London*, 1843

Incorporated Law Society. Calendar for 1882. 8vo. 820 pp. *London*, 1882

India-rubber, Gutta Percha, and Telegraph Works Company. Illustrated and Descriptive Catalogue of the Telegraph Apparatus and Stores manufactured by. 4to. 48 pp. *London*, 1874
[Presented by Colonel Bolton.]

International Electrical Exhibition (Crystal Palace). Catalogue. 8vo. 108 pp. *London*, 1882

Iron and Steel Institute. Journal of. 8vo. *London*, 1881

Ishie [T.] [*Vide* Japanese Telegraphs.]

Italian Telegraphs. Relazione Statistica sui telegrafi del regno d'Italia nell' Anno 1880. 4to. xc. and 203 pp. Plates. *Firenze and Roma*, 1881

Japanese Telegraphs. 7th Report of Director-General (T. Ishie). 8vo. 22 pp. 1881
[Presented by Mr. Stone.]

Joubert. [*Vide* Mascart et Joubert.]

Jounin. [*Vide* Galletti et Jounin.]

Kew Observatory. Report of the Committee for the Year ending October 31, 1881, with Appendices containing Results of Magnetical and Meteorological Observations made at the Observatory. 8vo. 22 pp. [*Proc. Roy. Soc.*, 1881.] *London*, 1882

Kirchoff [G.] [*Vide* Neumann, Dr. C.]

* **Kohlrausch** [F.] Ueber das elektrische Leitungsvermögen des Wassers und der Säuren. 8vo. 22 pp. [*Sitz. der Math.-Phys. Classe vom 5 Nov.*, 1875.] *Würzburg*, 1875

* —— Ueber das elektrische Leitungsvermögen wässriger Lösungen, insbesondere von den Salzen der Alkalien und Alkalischen Erden, den Aetz-Alkalien sowie einigen Säuren. Small 8vo. 19 pp. [*Königl. Gesellschaft der Wiss. und der G. A. Universität zu Göttingen, No.* 9.] *Würzburg* [?], 1877

* **Kohlrausch** [F.] **und Grotrian** [O.] Das elektrische Leitungsvermögen der chloride von den Alkalien und Alkalischen Erden, sowie der Salpetersäure in wässrigen Lösungen. 8vo. 39 pp. [*Ann. der Physik und Chemie. Band CLIV., No* 1.] Plates. *Leipzig*, 1875

* **Kuhn** [C.] Handbuch der angewandten Elektricitätslehre. 8vo. 1396 pp. *Leipzig*, 1866

Langdon [Wm. Edward] The Application of Electricity to Railway Working. 8vo. 315 pp. *London*, 1877
[Presented by Messrs. Macmillan & Co.]

* **Lardner** [D.] D.C.L., Editor. Museum of Science and Art. 12 vols. 8vo. *London*, 1854-56

La Rive [A. De] Ricerche sulle proprietà delle correnti magneto-elettriche. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1837

Leeds, Borough of. Report to the Town Council by the Joint Deputation from the "Purchase of Property Committee," the "Gas Committee," and the "Free Library Committee," upon the subject of Electric Lighting. 8vo. 135 pp. *Leeds*, 1882

Lightning Rod Conference, Report of. Edited by G. J. Symons, F.R.S. 8vo. 261 pp. *London*, 1882

* **Lintern** [Wm.] Magnetic Surveying and Angular Surveying. 8vo. 60 pp. [Weale's Rudimentary Series.] *London*, 1881

Liveing [E. H. T.] Directions for use of Patent Gas Indicator. 8vo. 4 pp. *London*, 1881

—— On an Instrument for the Detection and Measurement of Inflammable Gas in the Atmosphere of Mines. 8vo. 12 pp. *London*, 1881

Lodge [Professor O. J.] Electricity and Gas *v.* Smoke. 8vo. 20 pp. *London*, 1882

Maier [J.] [*Vide* Hospitalier, E.]

Marianini. Memoria sopra la teorica Chimica degli elettromotori voltiani semplici e composti. 4to. pp. 71 to 77. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1831

* **Marryat** [Capt.] R.N. A Code of Signals for the use of vessels employed in the Merchant Service, including a Cypher for Secret Correspondence. 8vo. Seventh edition. *London*, 1840

* **Mascart et Joubert.** Leçons sur l'Electricité et le Magnétisme. 8vo. 736 pp. *Paris*, 1882

Matteucci. Influenza del Calore sul Magnetisme. 4to. Parte Seconda. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1831

Maxwell [Jas. Clerk]. [*Vide* Campbell and Garnett.]

Meyer [H. R.] The Development of Electricity and the solution of the problem of the wires. 8vo. 15 pp. Plates. *Liverpool*, 1882

Moll. Sopra la forza magnetica che preudono le barre di ferro dolce sotto la influenza delle correnti elettriche. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1833

* **Musschenbroek** [P. Van] M.D. The Elements of Natural Philosophy. [Translated from the Latin, by J. Colson, M.A.] 2 vols. 8vo. *London*, 1744

Nairac. Sopra alcuni fenomeni di magnetizzazione. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1834

* **Napier** [James] F.C.S. A Manual of Electro-Metallurgy, including the application of the Art to Manufacturing Processes. 8vo. 152 pp. [*From the Ency. Met.*] *London*, 1852

Needham [L'Abbe]. Recherches sur la question si le son des cloches pendant les orages fait éclarter la foudre. 4to. 14 pp. 1781
By Exchange.

* **Neumann** [Dr. Carl] Die Elektrischen Kräfte. Darlegung und Erweiterung der von A. Ampère, F. Neumann, W. Weber, G. Kirchoff, entwickelten mathematischen Theorieen. Large 8vo. 272 pp. *Leipsig*, 1873

Newall [R. S.] Facts and Observations relating to the Invention of the Submarine Cable, and to the manufacture and laying of the first Cable between Dover and Calais in 1851. 8vo. 8 pp. *London*, 1882

* **Nicoll** [Hy.] Great Movements, and those who achieved them. 8vo. 456 pp. "The Electric Telegraph," p. 413. *London*, 1881

Nineteenth Century. [*Vide* Bury.]

Nobili [L.] Della pila di Volta. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1831

——— Note sul Magnetismo. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1834

——— Della distribuzione e degli effetti delle correnti elettriche nelle masse conduttrici. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1836

Nobili [L.] e **Antinori** [V.] Nuove esperienze elettro magnetiche. . . 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padovo*, 1832

——— Delle nuove calamite elettriche. . . 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1832

* **Oberbeck** [A.] Untersuchungen über schnell wechselnde electrische Ströme. 8vo. 31 pp. Plate. [*Ann. der Phys. und Chemie. Neue Folge.*] *Leipsig.*

* **Onimus** [Dr.] Guide pratique d'Electrothérapie. [*See* Bonnefoy.]

* **Parnell** [Major A.] R.E. The Action of Lightning and the Means of Defending Life and Property from its Effects. 8vo. 303 pp. *London*, 1882

Patent Office. Indexes, Alphabetical, for 1856, 1880, and 1881. *London.*

——— Indexes. Subject matter for 1879, 1880, and 1881. *London.*

Patent Office. Catalogue of the Library of Authors. Fcap fol. 715 pp. *London*, 1881

——— Abridgements of Specifications relating to Electricity and Magnetism. Division I.—Generation of Electricity and Magnetism. Part II. 1867-1876. 8vo. 150 pp. *London*, 1882

——— Abridgements of Specifications relating to Electricity and Magnetism. Division II.—Conducting and Insulating. Part II. 1867-1876. 8vo. 161 pp. *London*, 1882

——— Abridgements of Specifications relating to Electricity and Magnetism. Division IV.—Electric Lighting, Igniting, and Heating. Parts I and II. 1839-1876. 8vo. 126 pp. *London*, 1880

——— Abridgements of Specifications relating to Electricity and Magnetism. Division V.—Electro-deposition and Electrolysis. Parts I. and II. 1805-1876. 8vo. 273 pp. *London*, 1882

Peichl [M. J.] [*Vide* Collet, A.]

Philosophical Society of Glasgow. Reports relative to Exhibition of Apparatus for the Utilisation of Gas, Electricity, etc., held under the auspices of the Society, September to October, 1880. 8vo. 133 pp. *Glasgow*, 1882

Piccoli [D. V.] Le principali applicazioni industrali dell' elettricità all, Esposizione Internationale di Parigi del 1881. 8vo. 114 pp. *Roma*, 1882

* **Platts** [Rev. John]. The Literary and Scientific Class-book. 8vo. 492 pp. "Electricity," etc., pp. 157-185. *London*, 1830

Pogliaghi. [*Vide* Ferrini e Pogliaghi.]

* **Pouillet** [M.] Eléments de Physique expérimentale et de Météorologie. 2 vols. Septième édition. 8vo. Each 850 pp. *Paris*, 1856

* **Quincke** [G.] Ueber elektrische Ströme bei ungleichzeitigem Eintauchen zweier Quecksilber-Elektroden in verschiedene Flüssigkeiten. 8vo. 45 pp. Plate. [*Poggendorff's Ann., Band CLIII.*] *Würzburg*, 1874

* ——— Ueber electrische Ausdehnung. 8vo. 124 pp. [*Ann. der Physik und Chemie. Neue Folge. Band X.*, pp. 161-202, 374-414, 513-553.] Plate. *Leipzig*, 1880

Reis [Ph.] Autograph description of Telephone, dated 13th July, 1863. *Fredricksdorf*, 1863. [Presented by Mr. Wm. Ladd.]

* **Religious Tract Society.** Electricity: its Phenomena, Laws, and Results. 12mo. 184 pp. *London*, 1843

* **Reynolds.** Introduction to Natural Philosophy. 4to. 24 pp. 11 Sheets. Diagrams. *London*, 1850

* **Routledge** [R.] B.Sc., F.C.S. Discoveries and Inventions of the Nineteenth Century. Fifth edition. "Electricity," p. 359; "Electric Telegraph," p. 397. 8vo. 594 pp. *London and New York*, 1881

* **Rowell** [G. A.] Electric Meteorology. An Endeavour to show the General Agency of Electricity in the Causes of Rain and its Allied Phenomena. 8vo. 44 pp. *Oxford*, 1881

Rowell [G. A.] Electricity a principal cause in Meteorological Phenomena. 8vo. 56 pp. *London*, 1882.

Royal Engineers Institute. Professional Papers of the Corps of Royal Engineers. 8vo. *London*, 1882

Royal Institute of British Architects. Transactions. Session 1881-82. 4to. 239 pp. *London*, 1882.

Royal Institution. Proceedings. 5 Parts. 8vo. *London*, 1879-1881

Royal Observatory, Greenwich. Results of the Magnetical and Meteorological Observations, 1880. Large 4to. *London*, 1882

* **Sabine** [Rob.] The Electric Telegraph. 8vo. 428 pp. *London*, 1867

St. Pancras. [*Vide* Gibb, T. E.]

* **Santanello** [F.] Magica magneticœ. 4to. 108 pp. *Coloniæ*, 1623

Schäffler [Otto von]. [*Vide* Zetzsche, Dr. E.]

* **Scheffler** [Dr. H.] Das Wesen der Elektrizität des Galvanismus und Magnetismus. 8vo. 126 pp. *Leipzig*, 1882

* **Schellen** [Dr. H.] Die Magneto- und Dynamo-elektrischen Maschinen. 2nd edn. 8vo. 656 pp. *Köln*, 1882

Siemens [Dr. C. W.] F.R.S. The Electro-magnetic Practical System of Units. 8vo. 7 pp. *London*, 1883

——— Address to British Association. 8vo. 33 pp. *London*, 1882

Siemens [Dr. W.] Ueber das Projekt einer Elektrischen Eisenbahn. 8vo. 15 pp. *Berlin*, 1880

* **Siemens and Halske.** Das Universal-Galvanometer. 4to. 6 pp. *Berlin*, 1875

——— Distanzmesser [Ortsbestimmer mit magneto-elektrischer] Bewegungs übertragung. Large 8vo. 6 pp. *Berlin*, 1879

——— Die Elektrische Beleuchtung der Kaisergallerie. 8vo. 7 pp. [Separatdruck aus No. 251 der *National Zeitung*]. *Berlin*, 1879

——— Die Differential lampen. Large 8vo. 14 pp. *München*, 1880

——— Die Elektrische Beleuchtung auf dem Ocean-Dampfer "City of Berlin," mittelst der neuen. Differenziallampen. 8vo. 5 pp. [*Times, 30th Dec.*, 1879.] *Berlin*, 1880

——— Dynamo-elektrische Flachring-Maschine. Large 8vo. 3 pp. *Berlin*, 1880

——— Die Elektrische Eisenbahn zu Lichterfelde. 8vo. 16 pp. Plates. [*Glasers Annalen.* 1881. *Bd. VIII. Heft* 12]. *Berlin*, 1881

——— Electrische Beleuchtungs-Anlagen. 8vo. 10 pp. *Berlin*, 1881

——— Gelieferte Maschinen u. Apparate zu Electrischen Beleuchtungs-Anlagen. 8vo. *Berlin*, 1881

——— Elektrische Maschinen und Zubehör. Large 8vo. 30 pp. *Berlin*, 1882

——— [*Vide* Hefner v. Alteneck.]

——— [*Vide* Zetzsche.]

Simon. [*Vide* Ampère e Simon.]

Smith [Willoughby]. Induction. 8vo. 17 pp. Plates. *London*, 1882

Smithsonian Institution. Annual Report of the Board of Regents, showing the operations, expenditure, and condition of the Institution for 1880. 8vo. 772 pp. *Washington*, 1881
Exchange.

Society of Arts. Transactions. Part I.—Containing papers by E. Highton on Atmospheric Electricity. 4to. 144 pp. *London*, 1847

Society of Telegraph Engineers and of Electricians. Rules and Regulations recommended for the Prevention of Fire Risks from Electric Lighting. 8vo. 4 pp. *London*, 1882

——— Index to Journal of. [*Vide* Frost, A. J.]

Soemmering [S. T. v.] Der Elektrische Telegraph. 8vo. 23 pp. *Frankfurt*, 1863
[Presented by Latimer Clark, *Past President*.]

Solly [J.] The History and Development of Electrical Science. 8vo. 11 pp. Plate. *Dudley*, 1882

Spillan [D.] [*Vide* Teste, A.]

Stewart [Balfour] LL.D., F.R.S. Lessons in Elementary Physics. Crown 8vo. 383 pp. *London*, 1880
[Presented by Messrs. Macmillan & Co.]

Strouhal u Barus. Haltbarkeit der Magnete. 8vo. 53 pp. *Würzburg*, 1882

Sturgeon [W.] Ricerche sperimentali il termo-magnetismo dei corip omogenei. 4to. [*Fusinieri's Ann. delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1832

Symons [G. J.] F.R.S. The Snow Storms of January 17th to 21st, 1881. 8vo. 30 pp. Plate. [Excerpt from *Symons' Monthly Meteorological Magazine* for February and March.] *London*, 1881

——— [*Vide* Lightning Rod Conference.]

Tait. [*Vide* Thomson and Tait.]

Ternant. [*Vide* Hoskiœr.]

* **Teste** [A.] M.D. A Practical Manual of Animal Magnetism, containing an exposition of the methods employed in producing the Magnetic Phenomena. Crown 8vo. 406 pp. [Translated by D. Spillan, M.D., A.M.] *London*, 1843

* **Thompson** [Silvanus P.] B.A., D.Sc. The Storage of Electricity. Large 8vo. 19 pp. *London*, 1881

* **Thomson** [David P.] Introduction to Meteorology. 8vo. 487 pp. *London*, 1849

* **Thomson** [Sir Wm.] LL.D., D.C.L., F.R.S., and **Tait** [P. G.] M.A. Treatise on Natural Philosophy. Vol. I. Part I. New edition. Demy 8vo. 508 pp. *Cambridge*, 1879

Thomson [Sir Wm.] LL.D., D.C.L., F.R.S. Mathematical and Physical Papers. Vol. I. 8vo. 558 pp. *Cambridge*, 1882

——— *Vide* Collet, A.

* **Tiemann** [C.] Der electrische Telegraph. 8vo. 264 pp. *Berlin*, 1882

Todd [C.] Meteorological Observations made at Adelaide Observatory, 1879. Folio. 250 pp. *Adelaide*, 1881

* **Tomlinson** [C.] The Magnet familiarly described. 47 pp. *London*, 1861

* **Turkish Spy** [Marana (?)] Letters of a. 8 vols. 8vo. *London*, 1730

* **Tyndall** [J.] LL.D., F.R.S. Heat Considered as a mode of motion. A course of Twelve Lectures delivered at the Royal Institution in the season of 1862. 8vo. 468 pp. *London*, 1863

* **Tyndall** [J.] LL.D., F.R.S. Sound. A course of Eight Lectures delivered at the Royal Institution of Great Britain. 8vo. 341 pp. Second edition. *London*, 1869

United States, History of the Signal Service Army of. 8vo. 43 pp. *Paris*, 1881
[*See* Hazen.]

* **Urbanski** [Dr. A.] Theorie des Potenzials. Large 8vo. 142 pp. *Berlin*, 1864

* **Vallemont** [De.] La Physique occulte ou traite de la Bagnette divinatoire. Small 12mo. *Paris*, 1693

* **Vincentius Bellovacensis.** Speculum Naturale. 2 vols. folio. 1473-1476

Walker [A.] A System of Familiar Philosophy. 2 vols. New edition. 4to. *London*, 1802
[Presented by A. Graham, Associate.]

Watkin [Capt. H.] R.A. Report on Appliances connected with Artillery [Paris Electrical Exhibtion, 1881.] Fo. 8 pp. Plates. *London*, 1882

Webb [Walter]. [*Vide* Bower and Webb.]

Weber [W.] [*Vide* Neumann, Dr. C.]

Webber [Lieut.-Col. C. E.] R.E. The Lines of Communication of an Army in the Field, and their Working. 8vo. 50 pp. *London*, 1882.

* **Weber** [Dr. Heinrich]. Der rotationsinduktor seine theorie und seine anwendung zur bestimmung des ohm in absoluten maasen. La 8vo. 76 pp. *Leipzig*, 1882

* **Whewell** [Rev. Wm.] Astronomy and General Physics. Svo. 381 pp. *London*, 1834

* **Wiedemann.** Die Lehre vom Galvanismus. 3 vols. 8vo. *Braunschweig*, 1872-74

——— [G.] Die Lehre von der Elektricität. 8vo. 795 pp. Erster Band. *Braunschweig*, 1882

Wise [W. L.] [*Vide* Cooke and others.]

* **Wormell** [R.] D.Sc., M.A. Magnetism and Electricity. An Elementary Text Book for Students. 8vo. 260 pp. *London*, 1882

* **Wullner** [Dr. A.] Lehrbuch der Experimental-Physik. 2 Parts. Vol. II. Large 8vo. 1,352 pp. *Leipzig*, 1866

* ——— Compendium der Physik. Large 8vo. 2 vols. Zweiter Band—"Die Lehre von der Wärme, dem Magnetismus und der Elektricität." 704 pp. Erster Band—"Allgemeine Physik, Akustik, und Optik." 659 pp. *Leipzig*, 1879

Zantedeschi [F.] Esperienze riguardanti la direzione e l'intensità delle correnti magneto-elettriche. 4to. [*Fusinieri's delle Scienze del Reg. Lomb. Veneto.*] *Padova*, 1836

Zantedeschi [F.] e **Mayer** [F.] Nuove esperienze intorno all' origine della Elettricità terrestre. 4to. [*Fusinieri's Ann. del Scienze del Reg. Lomb. Veneto.*] *Padova*, 1832

Zeitschrift fur Instrumentenkunde. Vol. I. Large 4to. *Berlin*, 1881
By Exchange.

Zetzsche [Dr. K. Ed.] Einige neuere Einschaltungen zum telegraphischen Doppelsprechen. 8vo. 9 pp. *Chemnitz.*

——— Die Entwickelung und Ausbreitung der elektrischen Telegraphen. Large 8vo. 46 pp. *Chemnitz*, 1866

Zetsche [Dr. K. Ed.] Die Blockapparate für den Eisenbahnbetrieb von Siemens and Halske in Berlin. Large 4to. 11 pp. Plates. *Wiesbaden*, 1874

—— Der Börsentelegraph von Otto Schäffler in Wien. 8vo. 9 pp. Plates. [*Dingler's Polytechn Jl.* Bd. 215, S. 42. January, 1875.] 1875

—— Der Telegraph und der automatische Umschalter. 8vo. 19 pp. *Augsburg*, 1875

—— Einige Bemerkungen über die Verbindung des telegraphischen Doppelsprechens mit dem Gegensprechen. Large 8vo. 8 pp. 1875

—— Noch einige Bemerkungen über das telegraphische Gegensprechen und Doppelsprechen. Large 8vo. 15 pp.

—— Handbuch der elektrischen Telegraphie. Vols. I., II., and IV. 8vo. *Berlin*, 1877-78-81

—— Die Telegraphenapparate. Large 8vo. 58 pp. *Berlin*, 1880

* —— Handbuch der elektrischen Telegraphie. Parts I. and II. Vol. III. 8vo. *Berlin*, 1880-82

December 9th, 1882.

The PRESIDENT called upon Mr. E. Graves to propose a cordial vote of thanks of the Society to be presented to the President and Members of the Institution of Civil Engineers, for their kindness in continuing to permit the meetings of the Society to be held in the Institute.

Mr. E. GRAVES: In obeying your direction, sir, I have a very pleasing duty to perform, and one which it would be ungrateful in us to omit to discharge. To the liberality of the Institution of Civil Engineers we owe one contribution which I, as Treasurer, more especially value, *i.e.*, our funds are lightened by not having to provide ourselves with a meeting-place, for I doubt, if we had to find for ourselves that which has been so liberally placed at our disposal, whether we should have been able to invest the whole of the life compositions which we have received during the existence of the Society. The kindness which the Institution of Civil Engineers has shown is remarkable. It is not uncommon for halls to be placed at the disposal of Societies, more or less dependent upon that which owns the building, but here we are rent free in every sense of the word; we pay nothing for gas, nothing for cleaning, nothing for furniture—services which persons who receive the use of rooms are ordinarily called on to defray. Further, when I entered the room for the first time on the commencement of this

Autumn Session, I was struck by the transformation that had taken place. I remembered a large useful, convenient, but somewhat dingy amphitheatre. I observed one that had been blessed with rejuvenescence in all its parts. I have read somewhere that certain authors always found that the activity of their mental faculties developed and increased by working in suitable apartments, which meant that they were surrounded with appointments of æsthetic and artistic quality and abundantly decorated, and it may be hoped that, in future, the brilliance of our discourses will reflect the brilliancy of the hall in which they take place. The only thing that I see to lament is the absence of the electric light, because then we should have a characteristic illumination for some of the papers brought before us, but this is a matter of time only, no doubt. I have great pleasure in proposing the vote of thanks with which I am entrusted.

Mr. WIGAN seconded the vote. Though not practically engaged in electrical work, he had taken a deep interest in all matters connected with it, and also the Society since its formation; and an outsider sometimes saw as much of the game as those who played. The liberality of the Institution of Civil Engineers was greater than at first sight appeared, and its contrast came out very strongly when it was remembered that in the early days of the Society its members were much akin to watchmakers, whereas in the present day they had to make large machines, the principles of construction of which were on a par with those in which ordinary mechanical engineers themselves were concerned.

The vote was carried with acclamation.

Mr. LATIMER CLARK proposed a vote of thanks to the Local Honorary Secretaries of the Society, in various parts of the world, for their services. He pointed out their great utility to the Society in collecting subscriptions and recommending new members, for all of which they were recompensed by a vote of thanks, which they richly deserved. Many of them held high positions in foreign service, and he was sure that all present would cordially agree in the vote.

Mr. ALEXANDER SIEMENS seconded the vote, with full concurrence in Mr. Latimer Clark's remarks.

The vote was heartily carried.

The Secretary then read the following paper:—

THE APPLICATION AND EXTENSION OF TELEPHONIC COMMUNICATION IN JAPAN.

By T. J. Larkin.

As far as I have been able to ascertain, no application of the Telephone for police purposes or for train working has, up to the present, been made in this country. I beg, therefore, to offer a short description of what has been done in this direction in Japan, which may serve to illustrate the progressiveness of the Government officials and their practical appreciation of one of the latest triumphs of Western science. The town of Osaka (the second in the empire, and termed by some travellers the Venice of Japan, on account of the vast water network which divides it into sections, and the surprising number of bridges, large and small, which exist) is twenty-six miles south-west of the ancient capital of the country, formerly known as Miako, now called Kioto or Saikiyo. It has a population estimated by a recent census at a little short of 300,000, housed in wooden tenements rarely exceeding two stories high, which necessarily spreads it over a wide area of ground; and although a very large police force, wholly composed of men of the old two-sworded class, was distributed through the town, it seemed to experience no small difficulty in preventing the too frequent occurrence of lawlessness in the shape of serious fires caused by incendiaries, armed robberies, military emeutes, etc., necessitating the speedy concentration of bodies of police. The urgent need for rapid communication between the principal stations decided the local government to apply to the central government for the construction of telegraphic lines, and accordingly, in July, 1878, a system was established under my direction. No. 11 G.P. wire was erected, as far as possible upon existing poles, and separate lines were constructed from various points of our main lines. Nine offices, including the central, were opened, and Morse instruments were employed; at each of the branch stations two operators, and at the Central Station a full

staff, were provided by the Telegraph Department. Five lines radiated from the chief office: one of them connected it with the principal government telegraph office, thus placing it *en rapport* with Tokiyo (the new name for Yedo.) The two large gaols of the town were also connected to the nearest police office. Single-stroke bells, such as we used on the railway line, were employed, and a set of signals were arranged, by which rioting or other disturbances occurring could be indicated to the police office.

Shortly after all had been completed, it was perceived that, although a rapid interchange of messages and instructions was at all times of the highest importance, there was not that regular flow of message work characteristic of the commercial offices to which the selected operators had been accustomed: their new duties amongst the police proved irksome to them, and many applied to be taken back. This being the state of affairs, the mere suggestion of telephones was sufficient to create certain interest, and when the simplicity and economy of their maintenance became known, the local government gladly grasped at what promised to be an escape from a dilemma, and I was asked to make some experiments, which proved that telephones could safely be substituted for the Morse instruments. The necessary alterations were forthwith put in hand and speedily carried out. Bell's telephones, each set consisting of bell, hand, and wall telephones, were purchased from private agents, but as there was not a sufficient supply at the time in the country, the Government Department in Tokiyo undertook to make up the required number. Such surprisingly good copies of the American originals were made, it became a difficult matter to tell them apart. (I may remark, *en passant*, that American or European patent laws do not extend to Japan, and, as far as I can learn, the new law codification makes no mention of them. Hence telephonic apparatus may be copied and made by one department and sold to another; and, if imitation be considered the sincerest flattery, Messrs. Siemens Brothers are no doubt pleased with the fact that their single galvanometer Morse instruments, lightning guards, etc., are the favourite models adopted by the Mechanician's branch in Tokiyo, copies of which are supplied to all new lines and stations.)

At each station two intelligent policemen received a few leading instructions in the mode of using the apparatus, the necessity for keeping all screws tight, and how to proceed in case of stoppage of communication. A small compartment partitioned off from one of the rooms, in order to cut off as much as possible extraneous disturbance, received the apparatus. In making the change to telephones a slight increase in the number of stations was made, and on one line four telephone stations were intermediate. A mode of signalling was adopted by which each office would know which station was being called. On each line the head office answered for one ring, the second station for two rings, and so on to the last; a due pause occurred between every complete call, confusion was quite avoided, and it was astonishing how quickly the policemen took to their new work. My periodic visits convinced me that the system, as arranged, was working well: the full control the department was enabled to exercise over the remotest parts of the town was acknowledged with much satisfaction. One of the lines is about eight miles in length, and contains four stations: it runs for a short distance upon poles, with a number of busy wires through which powerful currents are constantly circulating, and then in company with a branch commercial wire. I watched the working of this circuit carefully, being afraid it would prove troublesome; but it seemed the police experienced no difficulty in communicating—in fact, articulation was surprisingly loud and distinct, although induction interference was quite marked.

Separate lines would probably have been built for the telephone circuits, if the idea of employing telephones had preceded the construction of Morse lines; but the question of expense stood forward, and decided the department to apply the apparatus to the existing lines, without making further alterations.

The Minister of Public Works visited Osaka, and, referring to the working of the police telephones, asked how I accounted for the fact that elsewhere they had to build separate lines in all cases. My answer, first, embodied the reluctance of the local government to incur fresh expenses; and, secondly, pointed to the fact that the police in Osaka commenced their first experience

upon lines running in the neighbourhood of other wires, and accustomed themselves to the slight inconvenience arising from induction.

I have here only referred to Osaka. The Police Department in Tokiyo had one or two telephone lines at this period, with a full system of Morse lines, and the majority of the police offices there accepted commercial messages. In Yokohama a system of lines radiated from the central police station to the various branch stations and the prison, and was worked successfully by telephones.

The Government House and head police office, the prison and branch police office in Hiogo, were shortly after connected by telephones.

The palace of H.I.M. the Mikado, at Akasaka, in Tokiyo, enjoyed the use of the first telephonic line: it was connected to the offices of the Public Works Department, thus fittingly inaugurating the reception of the invention in the empire.

Before any telephonic apparatus was sent out to the stations, every part was carefully examined, and an adjustment as delicate as possible and consistent with safety given to it, and to this supervision the absence of complaint and trouble may fairly be ascribed.

I shall now turn to some experiments conducted on the single line of railway, existing between Hiogo and Otsŭ, a distance of 57 miles, containing seventeen stations, of which, during normal periods of traffic, seven were crossing stations. The block and Bell two-wire system was worked throughout; seven principal stations were served by a Morse wire. A somewhat amusing incident occurred at Suita, the first crossing station from Osaka, on the Otsŭ side, in which Prince Heinrich of Germany was the hero, and which, perhaps, had some little influence in hastening the introduction of the first railway telephone in Japan, although it is but fair to say that the subject of their adoption had been previously discussed. The Imperial Prince, with some officers of his ship, went up for a day's shooting to a place near Suita, and it seemed they unconsciously trespassed upon a preserved pond, full of duck, the owners of which were already much irritated with foreign sportsmen shooting over their property, regardless of

notices in English and French. The villagers surrounded the Prince and party. The latter, by donning shooting gear, were completely divested for the nonce of all pretensions to rank; and the simple villagers, even if told in the best Japanese that they were offering opposition to an Imperial Prince, to whom their Government would have been very desirous to accord almost any privilege to make his visit to Japan agreeable, would naturally scout the idea as a mere subterfuge, so firmly rooted in the native mind is the connection of officialdom with pomp and circumstance. The policeman of the village eventually insisted upon their return to Osaka, to prefer a complaint against them. At the railway station they could not send a telegraphic report of the case, as only block signalling instruments were in use, and on account of the misunderstanding with the police, they missed their train, and had to go to Osaka by jinrikisha (a light two-wheeled chair pulled by a man between shafts, the ordinary means of locomotion throughout the country). The Suita policeman followed them. In Osaka they were detained till rather a late hour, before the Governor, who was communicated with, could be made to understand the facts, when of course an immediate apology was tendered to His Highness. The affair, when it became known, created some excitement, causing an exchange of official correspondence, and a public apology on the side of the Government.

The railway authorities, although not in any way censurable, still saw that a speaking telegraph at Suita might have explained matters at an early stage; however, the remote contingency of such another important case occurring would hardly warrant the insertion and maintenance of a Morse instrument, but a set of telephones promised to meet the requirements of the position, and their employment was decided upon. A light line of hinoki poles (*chamæcyparis obtusa*) was erected on the side of the rails, opposite to the main line poles, every possible precaution being observed on this occasion to keep the new line free from induced currents. No. 11 wire was used. The shortest lateral distance between the new wire and the main lines, about eleven feet, occurred at the crossing of two iron girder bridges, which were employed to support both sets of poles. One of the bridges was

nearly a quarter of a mile in length. Only at one point the two lines had to cross at right angles. The vertical distance between the lowest wire of the main line and the telephone circuit was fully twelve feet. The earths at Suita and Osaka were kept separate from those of the blocks, and were taken from the rails. An appreciable amount of Morse working was however noticeable on joining up the apparatus, but not of any consequence to affect conversation. I made it out to proceed principally from our duplex line, situated on the top arm of the main-line pole carrying eleven wires. I intended, when leisure afforded it, to ascertain if an alteration at the bridges would have cleared away induction, but as it did not amount to a necessity, my departure from Japan has left the question for some other experimenter to solve.

The breakdown of a train's engine close to Suita, shortly after this line was opened for use, presented a very good opportunity to test it in a case of urgency. An auxiliary engine was asked to be despatched from Osaka, at which station one is always kept in readiness, and the traffic, which under the ordinary state of things would have been very much delayed, was quickly restored to its usual groove. This line was completed in July, 1880, and was terminated in the offices of the stationmasters, who also were responsible for the block-working; but I am rather of the opinion, from what I know, that the power conferred by the telephones caused the blocks between Suita and Osaka to assume a secondary importance. Shortly after this circuit was established, I was asked to provide a similar one between the railway stations of Hiogo and Sannomiya, the distance being only one mile, but its shortness caused a certain inconvenience. When the train arrived at Hiogo (the terminus) it had to be turned within a few minutes for the next journey, and instructions which should have been transmitted by the Morse instrument were often rendered useless by two or three minutes' inattention, or, which was quite as bad, by stations fighting for the circuit. The only remedy was a telephone wire, which, when finished, completely satisfied them. They were thus enabled to forward any instructions during the five minutes occupied by the train moving between the two stations.

These two lines cost very little to construct, and, to show how thoroughly their utility was recognised, it was contemplated to provide every station with like facilities. A letter in September, 1880, from the Commissioner of Railways, asked me to furnish an estimate for the construction of a telephone circuit along the whole railway line.

By the employment of telephones between the different railway stations a distinct advantage would be derived, if a certain system were arranged. Supposing the engine which broke down at Suita Station to break down midway between the latter place and Osaka ($2\frac{1}{2}$ miles from either side), considerable delay would have occurred in this case, as a man would have had to go back to inform Osaka Station; but we will assume that the telephone circuit has been so arranged beforehand, that at a minimum distance, say, one mile from each station, the wire has been shackled at every few poles, and sufficiently low to allow of its being cut by the guard of the train, who is in possession of instructions, in case of any accident causing a stoppage, to simply break the cross-connection, the result would be that the bells at both stations would refuse to ring, and if the stationmasters were instructed to regard the stoppage of the bell in connection with the non-arrival of the train at the usual time, to denote an accident to it, they could take immediate measures to render assistance. To go one step further, if the guard of the train had telephonic apparatus supplied to his van, and knew how to use it, the stoppage could be made known within a few moments to either side.

Bell's telephones would of course be well adapted for an office of this nature. To be in a position to clear a busy single line quickly, when a stoppage of such a kind takes place, is well worth the cost of apparatus.

I do not say the Railway Department intends to adopt a system of this kind; it was suggested by me, and if not already applied it is possible it may have a trial. The charge I had of the railway telegraph system commenced with the opening of the line in 1874, and extended over seven years, and I have been led to form my own conclusions respecting the value and the inherent defects of the block system, which have taught me that no great reliance

can be placed on its working. The sad accident last year on the North London Railway, at Canonbury, has demonstrated the fallibility of the system to successfully provide for certain conditions of traffic. The distinction between "permissive" and "positive" block, sent on the bell instrument, would well puzzle abler heads than those of signalmen. A telephone circuit between the two cabins would, I believe, have enabled the signalmen at Finsbury and Canonbury Junction to properly regulate the traffic, and prevented the loss of life, which was shown to have been caused by a fatal misconception concerning the meaning of certain arbitrary signals.

What has been effected by the Police and Railway Departments of Japan may furnish material for some reflection. Here, in Japan, we see a nation possessing a fossil civilisation suddenly awaking from its slumber of ages, turning and claiming to share with us the benefits of the wonderful inventions of our countries, readily applying them to accomplish certain ends, and showing us, in the line of application, we may perhaps take a hint from young Japan.

A vote of thanks was accorded to Mr. Larkin for his paper.

The PRESIDENT: The scrutineers have handed me a list showing the names of the Officers of the Society for the forthcoming year, who have been elected by the ballot this evening. It is as follows:—

President.

WILLOUGHBY SMITH.

Vice-Presidents.

Professor W. G. ADAMS, F.R.S.	Professor D. E. HUGHES, F.R.S.
C. E. SPAGNOLETTI, M. Inst. C.E.	Sir CHARLES BRIGHT, M. Inst. C.E.

Honorary Treasurer.

EDWARD GRAVES.

Honorary Secretary.

Colonel FRANK BOLTON.

Members of Council.

W. S. Andrews.
William T. Ansell.
Professor W. E. Ayrton, F.R.S.
E. B. Bright.
T. Russell Crampton, M. Inst. C.E.
H. G. Erichsen.
H. C. Forde, M. Inst. C.E.
Dr. J. H. Hopkinson, M.A., F.R.S.
J. Fletcher Moulton, F.R.S.
Alexander Siemens.
Augustus Stroh.
C. F. Varley, F.R.S.

Associate Members of Council.

Lieut. Arthur H. Bagnold, R.E.
Shelford Bidwell, M.A., LL.B.
J. C. Lamb.

A ballot then took place, at which the following were elected:—

As Foreign Member:

Eli T. Starr.

As Associates:

William Mortimer Foxcroft. | Frederick Macrae-Keith.

As Students:

Frederic William Ford. | William John Hancock, Junior.

And the meeting was declared adjourned until Thursday evening, January 18th, 1883.

ORIGINAL COMMUNICATIONS.

RECENT PROGRESS IN TELEPHONY.

By William Henry Preece, F.R.S.

Paper read at the Meeting of the British Association, held at Southampton, 1882.

The Telephone was first introduced to the British public at the meetings of the British Association. In 1876, at Glasgow, Sir William Thomson startled his hearers by announcing that he had heard, in Philadelphia, Shakespeare quoted through an electric wire, by the aid of the invention of Mr. Graham Bell, which he then pronounced to be "the greatest by far of all the marvels of the electric telegraph." In 1877, at Plymouth, I had the pleasure of showing in actual operation the finally developed instrument now known as the Bell Telephone, which I had just brought over from America; and conversation was actually maintained between Plymouth and Exeter. Five years have elapsed since then, and it is fitting that the British Association should hear of the progress of this astonishing apparatus.

In 1877, it was a scientific toy; it has now grown to be a practical instrument. £1,550,000 capital is already embarked in its extension in England, and it is earning a revenue of £109,000. Hitherto it has been practically a monopoly in the hands of a private company, who hold the controlling patents, and of the Post Office, who possess the controlling power, but this monopoly has been broken, and we are about to witness severe competition. It is often said that competition in any business will have the effect of reducing the rates charged to the public, but the experience of the past in railways and telegraphs teaches an opposite lesson. Undue competition tends to lower the rates for a time, but it eventually leads to amalgamation—to the absorption of the weak by the strong—to swollen and watered capital, and, finally, in many cases to higher rates to a too-confiding public. Competition,

however, induces better service, and ultimately, in this respect, the public gain.

The free traffic in patents, however, leads to jobbery and speculation of the worst type. We have recently seen a mania for electric speculations that almost rivals the South Sea Bubble period. The public have wildly rushed into ill-matured schemes that have swollen the purses of gambling promoters, have turned the heads of inventors, have retarded the true progress of the beneficial application of this new science to the wants of man, and have thrown away millions upon imperfect schemes. Much has been said against the monopoly of the Post Office in telegraphic business, but at any rate it has the merit that it has checked the rapacity of company promoters and patent-mongers in that branch of the practical application of electricity, while no one can assert that it has checked the progress of telegraphy. During the first week that the telegraphs in this country were transferred to the State, the total number of messages transmitted was 26,000, while in the week ending August 11th it amounted to 724,000. There is no inventor who can assert that his scheme has not received proper consideration, nor show a real improvement that has not been adopted and remunerated; while the improvements of the Post Office itself are freely adopted by other countries, and America itself—the home of the inventor—has found the advanced system of England worthy of acceptance.

Receivers.—The original telephone receiver of Bell has scarcely been improved upon: it remains in form and construction very nearly the same as that which I exhibited in 1877 (Fig. 1). The perfection of its working depends upon the truth and perfection of its manufacture. It is now more solid and substantial than it was at first, more powerful magnets are used; but still it is the same simple, marvellous, and beautiful instrument that I brought over from America. Mr. Gower has increased its loudness by varying the form of its various parts, and using very powerful horse-shoe magnets of peculiar form (Fig. 2); but experience shows that loudness is always obtained at the expense of clearness of articulation; and, although for many purposes the Gower-Bell instrument, which is adopted by the Post Office and is now in use to

connect together all the sections of the British Association scattered through the town of Southampton, is more practical, nothing for delicate articulation surpasses the original Bell.

The Paris Exhibition of last year, so fruitful in electrical novelties, did not bring forth any marked improvement in telephonic apparatus. It was noticeable chiefly for its practical

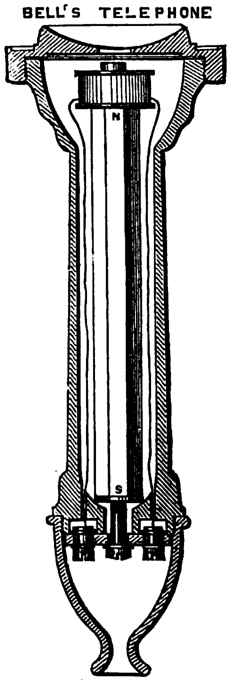


FIG. 1.

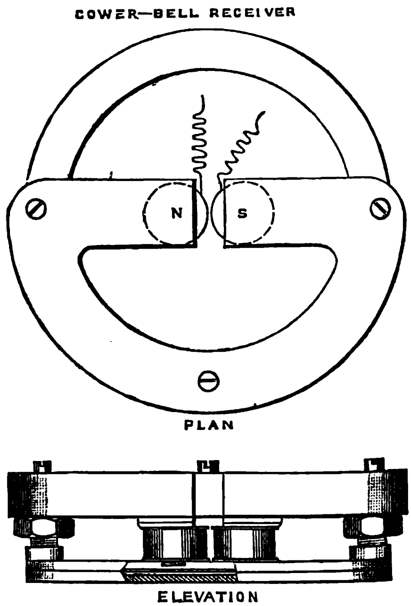


FIG. 2.

applications of the telephone, and particularly to the transmission of singing and music to a distance. M. Ader's modification of Bell's receiver is that almost universally used in Paris (Fig. 3). It is a very handy, pretty, and convenient form. He utilises a principle which he calls "surexcitation." A thick ring of soft iron is inserted between the ear-piece and the diaphragm, and this is

said to increase the attractive power of the little horse-shoe magnet upon the vibrating iron diaphragm. A simple experimental apparatus of M. Ader's shows that there is some foundation for this fact: when a thin steel spring is adjusted close to the poles of a magnet without being attracted by them, the near approach of a mass of iron to the spring will cause it to be attracted by the magnet.

D'Arsonval has also modified the Bell receiver (Fig. 4). He has placed the coil in a powerful magnetic field of annular form, and has thereby concentrated the lines of force upon the induced coil. He brings the whole coil within the influence of the field. The effects are said to be magnified, and the increased loudness not

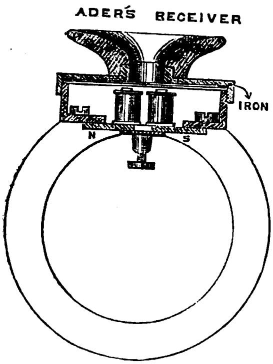


FIG. 3.

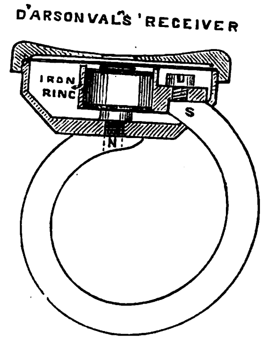


FIG. 4.

accompanied by the usual loss of articulation. Speech is reproduced without any change of *timbre.*

Telephone receivers of the Bell type are all based upon the magnetic effects of currents of electricity flowing around magnets or bars of soft iron.

The rapid and rhythmic magnetisation and demagnetisation of a bar of iron, or the increment and decrement of the magnetism of a magnet, will produce molecular disturbances, in its own mass and in the matter about it, that lead to the oscillatory motions of the whole which produce sonorous vibrations that can be made manifest by various devices, and particularly by that patented by Graham Bell.

Other principles of electricity have also been utilised for telephonic receivers.

For instance, Mr. Edison used the electro-chemical effect. The decomposition of a chemical solution in paper or on chalk, by the passage of currents through it, produces a modification of the friction of two moving surfaces, which can reproduce sonorous vibrations, and the result is a very loud-sounding apparatus. I myself had the pleasure, in 1880, of submitting to the Royal Society a receiver based on the electro-thermal effects of the current. The passage of a current through wires always heats them, and therefore produces expansion. If the wire be made fine enough, the heat is generated and dissipated so rapidly, the expansion and contraction are so quick, that sonorous vibrations are the result. Although I was able to speak through it very clearly, I have not as yet developed this instrument into a practical form. Professor Dolbear has recently utilised the electrostatic effects of currents. His receiver is even more simple than that of Bell. Two flat circular discs of metal are rigidly fixed very close to each other in an insulated case of ebonite. When one disc is electrified positively by a charge of electricity, the other is electrified negatively by induction. These two opposite states produce attractions varying in force with the strength of the signals sent, and the result is that, when telephonic currents are transmitted, we obtain sonorous vibrations, and, consequently, the reproduction of speech.

Many other forms of telephone receivers have been devised and exhibited, in fact I have recently seen quite a crop of them; but as they involve no new principle, and introduce no particular improvement, having been brought out chiefly to try to avoid existing patents, I pass them over, and proceed to the next branch of my subject.

Our present Patent Law is, unfortunately, in so disorganised and chaotic a condition, that evasion is often possible, and hence the questionable morality of doing a thing in another way, in order to avoid the incidence of a royalty, is practically encouraged.

The possession of a patent is now no guarantee of property: it is granted without any discrimination, and cannot be upheld without tedious litigation and wasteful expenditure before a

non-technical and scientifically incompetent tribunal. We therefore cannot hope for any virtue in English inventors or security for real improvements until our law is thoroughly revised. The question is before the House of Commons, and, when wordy agitators have fully exhausted the patience of our legislators, we may hope for some attention to so real and pressing a want.

Transmitters.—The great novelty and peculiarity of Bell's telephone was that the receiver and transmitter were similar and reversible. Sonorous vibrations of air impinging on an iron disc caused it to vibrate in front of a magnet around one pole of which a portion of an electric circuit was wound. These vibrations of a magnetic substance in a magnetic field produced currents of electricity in the coil of wire on the magnet, varying in strength and direction with the sonorous vibrations, which, proceeding along a wire to a distant station, there varied the magnetic strength of a similar magnet so as to vary its attractive force on a similar disc, by which it reproduced the motions of the first disc, and thus, reproducing the sonorous vibrations of the air, repeated speech. The currents, however, were very feeble; much energy was lost *en route*, and the effect scarcely attained a practical standard. Mr. Edison showed how to strengthen these currents. Taking advantage of a peculiar property of carbon which was supposed to vary in electrical resistance with the amount of pressure brought to bear upon it, he caused the vibrating disc which was spoken against to press upon a button of carbon, and so to vary the strength of a current of electricity passing through it. This varying current, passing through the primary wire of an induction coil, set up in the secondary coil more powerful currents than the Bell instrument produced, and caused louder and more marked effects at the receiving station. Professor Hughes went a step further. He found a combination of materials that were directly affected by sonorous vibrations, which he called a "microphone," and he proved that the effect of the carbon transmitter of Edison was not due to any influence of varying pressure on the mass of the carbon, but was a phenomenon of loose contact. He found a new fact in nature, and he startled the scientific world by introducing an instrument which did for minute sounds what the microscope had

already done for minute objects. By the light thrown on the theory of the instrument by Hughes, Edison's carbon transmitter has been so improved by Blake, Hunnings, Moseley, Anders, and others, that little apparently remains to be done. The telephone as a speaking instrument is now well nigh perfect. It is quite possible to swear to a friend's voice at 100 miles distance. The difficulty of making the telephone a practical instrument under all circumstances is not due to any defects in the instrument itself, but to disturbing influences external to it, and consequent on its surroundings. The very perfection and sensitiveness of the apparatus itself are its chief enemies.

The true action of the microphone, or carbon-transmitter, is very little understood: it introduces into a closed electric circuit, through which a current is flowing, a resistance which, varying exactly with the sonorous vibrations impinging upon it, causes the current to undulate in a way exactly analogous to the varying sound waves. This effect is generally assumed to be due to a greater or less intimacy of electrical contact between two semi-conducting surfaces abutting upon each other; but there is now little doubt that it is due to effects of heat generated by the passage of electricity between two points in imperfect contact, whose relative distance is variable. Carbon is the best material for the purpose—first, because it is inoxidisable and infusible; secondly, because it is a poor conductor; and, thirdly, because it has the remarkable property of having its resistance lowered when it is heated—the reverse of metals.*

The resistance of microphones is very variable: some only give 1^{ω}, while others give 10^{ω}, 25 , and some even 125^{ω}. The best transmitters that I have worked with (Moseley's) gave an average of 20^{ω}.

Attempts have been made to apply mathematical analysis to the determination of the best form and arrangement of microphones, but at present the microphone defies mathematics.

Theory would lead to the conclusion that a carbon-transmitter should have the lowest possible resistance, but practice does not confirm that idea.

* This observation is due to Mr. Shelford Bidwell.

Theory again asserts that the resistance of the secondary coil of the induction coil should be equal to that of the line it works, but practice proves the very reverse. On a line giving nearly $1{,}800^{\omega}$ resistance, the best effects were produced with a secondary wire of only 30^{ω} resistance. The fact is, that the conditions due to heat in the microphone, and to self-induction in the induction coil, are very complicated, and are not yet sufficiently understood to bring the phenomena they affect within the region of mathematical analysis.

Accessories.—I do not intend to speak here of the bells, calls, switches, etc., used in carrying out telephonic operations: there has been nothing that is particularly novel introduced, or that was not previously used in telegraphy. In fact, the whole operations carried on in connection with the so-called "exchange" working are simply telegraphic, and are still in a somewhat tentative condition.

Long-distance Speaking.—I have said that the difficulty in speaking is chiefly due to the environment of the wires employed. Were we to erect a wire from Land's End to John o' Groats, upon lofty separate poles and away from all other wires, there would be no difficulty whatever in speaking between those two places. Conversation has been held in America over 410 miles; in Persia it has been effected between Tabreez and Tiflis, 390 miles apart; in India, over a distance of nearly 500 miles; in Australia, of 300 miles; but in all these cases it was done either at night or under exceptional circumstances, and in all cases the wires were overground. Had they been underground or submarine, the case would have been very different. Conversations have been held between Dover and Calais, between Dartmouth and Guernsey, and between Holyhead and Dublin, but I know of no case where any persons have spoken through more than 100 miles of submerged cable. The reason of this diminution of speaking distance is due to the electrostatic capacity of the telegraph line, which absorbs the minute quantity of electricity that makes up the currents employed for telephonic purposes.

In every submarine cable, before a signal can be made at the receiving end, the whole cable must be charged up with electricity,

and if there be not sufficient electricity sent in to effect this purpose, practically no signal appears at the distant end. With telephone currents on long cables the whole of the electricity is, as it were, swallowed up—that is, none appears at the distant end, or, if it does appear, it is rolled up in one continuous wave, bereft of those rapid variations that reproduce sonorous vibrations. The newspapers said that the sound of the bombardment of Alexandria was heard at Malta; but, in the first place, the experiment was not tried, and, even if it had been tried, it could not have succeeded. The use of underground wires very seriously impedes telephonic extensions, and with our present apparatus and present knowledge we cannot readily speak over greater distances than 20 miles.

Disturbances.—But there are other disturbing influences at work of more serious import.

When two or more telephone wires run side by side, what is said on one can be overheard on all the others; and when a telephone wire extends alongside telegraph wires, every current on the telegraph circuit is repeated in the telephone, leading to a hissing, frying, bubbling sound that is not only very irritating, but which on busy lines entirely drowns speech. When music is transmitted on one wire, it can be heard equally well on all wires running parallel and contiguous. This is due to induction and to leakage.

(A.) *Induction.*—Induction is a term employed to designate the peculiar influence which electrified and magnetised bodies exert upon conducting and magnetic masses in their neighbourhood. If two wires run side by side for some distance, every current of electricity sent upon one wire will produce two currents in the contiguous wire, the one at the commencement and the other at the termination of the primary current of electricity. The greater the intensity, and the more sudden and abrupt the commencement and the ending of the inducing current, the greater effect it has on the induced wire. Those instruments, consequently, which reverse their currents the most rapidly and suddenly, produce the greatest disturbance. The powerful alternative and intermittent currents used for certain electric light systems are death to telephones: they

cause an incessant roar that renders speech an impossibility. There are some apparatus in telegraphy that require very powerful currents to work them, which are equally detrimental. Many attempts have been made to cure this evil.

1. The sensitiveness of the receiver has been reduced to lessen the influence of the disturbing currents, and the strength of the telephonic transmitting currents has been increased so as to overpower the induced currents.

2. The influence of one wire on the other has been screened off by inserting metal coverings in connection with the earth between them.

3. The suddenness of the rise and fall of the inducing currents has been modified by the insertion of condensers or electro-magnets.

4. Counterbalancing or neutralising effects have been set up by counter-induction apparatus.

But all these plans, and many others, have been proved either only partially successful or wholly abortive; the only effective mode of curing the evil at present practically used is to employ a complete metallic circuit so contrived that the two wires are in very close proximity to each other, or that they twist round each other, so as to maintain a mean average equality of distance between themselves and the disturbing wires. When we have the two wires of a circuit kept at the same mean distance from the disturbing causes, however near they may be, the influence on each must be identically the same, and as the one is used for going and the other for returning, the similar influences must be opposite in direction, and they must therefore neutralise each other. This plan, which was originally devised for underground wires by Mr. Brookes, of Philadelphia, was found to be absolutely true in practice, and the Post Office, having laid down many hundreds of miles on this system with perfect success, invariably constructs its circuits both underground or overground in this way. It is, of course, more expensive than a single wire, but the great gain—the absolute freedom from overhearing, the privacy, and the absence of crackling—is well worth the extra cost. Wires in submarine cables are invariably laid up with a twist, so that no special contrivance is needed on such wires, and in underground

wires not laid up together as cables they are, as a rule, so close to each other that twisting is unnecessary; but for overground purposes twisting is essential, and special arrangements have to be carried out. Professor Hughes showed how this was to be done,* and Messrs. Moseley carried it out practically in the neighbourhood of Manchester. The plan adopted by the Post Office for *two* and for *four* wires is shown by the diagram (Fig. 5). It is simply and easily carried out, and entails no practical difficulty whatever.

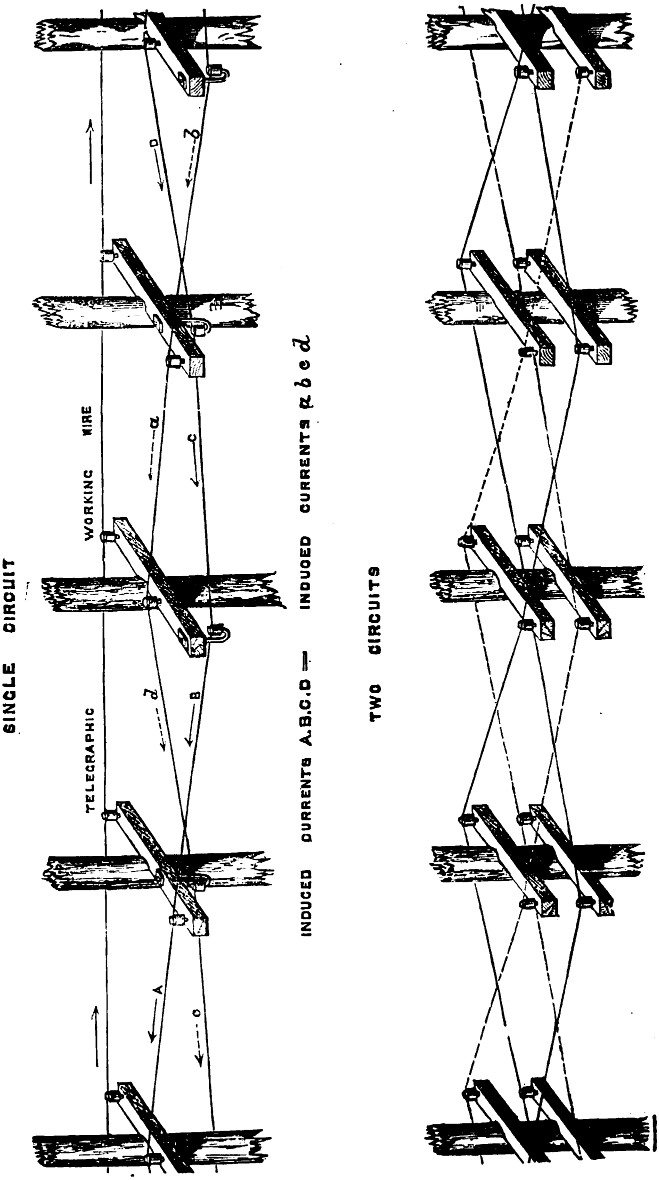
In the neighbourhood of Manchester there are over 400 miles of overground double wire twisted on this plan, working efficiently and thoroughly. I have spoken to a friend 76 miles off, through wires that were erected on poles carrying busily-occupied telegraphic currents, without disturbance or difficulty.

(B.) *Leakage.* — The double-wire system is only absolutely effective so long as the insulation is good. The moment insulation fails, connection with the earth is made, and then we have disturbing causes due to currents flowing through the ground, which are increased in proportion to the deterioration of the insulation. Hence, good insulation is essential to telephone working.

The discovery of the telephone has made us acquainted with another phenomenon. It has enabled us to establish beyond doubt the fact that currents of electricity actually traverse the earth's crust. The theory that the earth acts as a great reservoir for electricity may be placed in the physicist's waste-paper basket, with phlogiston, the materiality of light, and other hypotheses. Telephones have been fixed upon a wire passing from the ground floor to the top floor of a large building, the gas pipes being used as a return, and the Morse signals sent from a telegraph office 250 yards away have been distinctly read; in fact, if the gas and water systems be used, it is impossible to exclude telegraphic signals from the telephone circuit. There are several cases on record of telephone circuits miles away from any telegraph wires, but in a line with the earth terminals, picking up telegraphic signals. When an electric light system uses the earth, it is stoppage to all telephonic communication in its neighbourhood. The

* *Journal of the Society Telegraph Engineers*, Vol. viii., p. 170.

Fig. 5.


SINGLE CIRCUIT
TELEGRAPHIC WORKING WIRE
INDUCED CURRENTS A.B.C.D = INDUCED CURRENTS a b c d
TWO CIRCUITS

whole telephonic communication of Manchester was one day broken down from this cause, and in the City of London the effect was at one time so strong as not only to destroy telephonic communication, but to ring the bells. A telephone circuit using the earth for return acts as a shunt to the earth, picking up the currents that are passing, in proportion to the relative resistances of the earth and the wire. The earth offers resistance, and consequently obeys the law of Ohm; hence it is not only essential for a telephonic system that the earth should not be used on any electric light system, but it is also desirable that the earth should be eschewed for telephonic purposes. Thus, the double-wire system adopted by the Post Office and by the Société Générale des Telephones of Paris, not only cures the ill effects of induction, but it materially diminishes the disturbing influences of earth conduction. The four-wire system of the Post Office effectually checks leakage from one wire to the other,—cross contact, as we call it in England,—for each wire of the same current is always on a different supporting arm.

A telephone circuit when in connection with the earth gives distinct evidence of every visible flash of lightning, however far off the thunderstorm may be. No difference in time has been observed between seeing the flash and hearing the crash.

It is said that, if a telephone be connected between the gas and water systems of a house, distinct evidence of every flash can be heard. There have been several cases of persons being knocked down while experimenting during a thunderstorm, but no personal injury has been sustained, although the apparatus itself is frequently damaged. In England, at present, we have not found the damage done sufficient to justify the employment of lightning protectors. The use of double wires diminishes the danger to a minimum. On the Continent and in America, however, when one wire only is used, telephones are invariably protected by lightning arresters.

There are certain natural currents flowing through the crust of the earth. They are called "earth" currents, and at times acquire such energy, that, with a telephone pressed to each ear, I have been told, although I have not experienced it, that the noise

made is as though "your brains were boiling." This is due to the intermittent currents produced by the polarisation of the earth plates.

M. Van Rysselberghe has recently spoken between Paris and Brussels upon a wire nearly 200 miles long, which was used at the same time for ordinary telegraphy, but the experiment was made early in the morning (4 a.m.), and was effected by retarding the telegraphic currents, so as to modify the suddenness of their rise and fall, by means of condensers and electro-magnets. I am

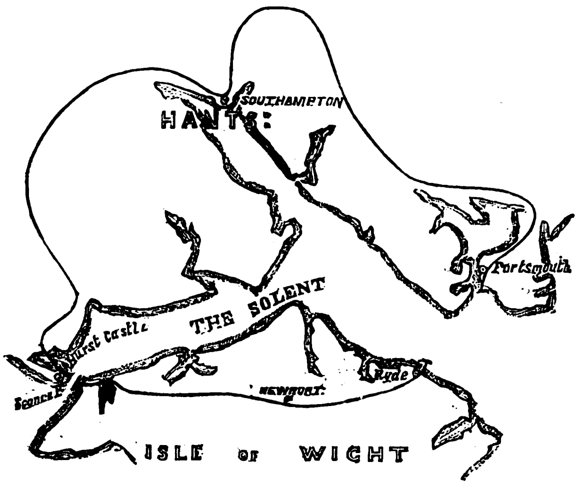


FIG. 6.

unable to understand the advantage of any gain in speaking on a wire which is detrimental to telegraphic communication. Speed is of more importance than speech, and we can telegraph much faster than we can speak. In England speed is everything, and we eliminate every influence that retards speed—condensers and electro-magnets in telegraph circuits are out of the question. M. Van Rysselberghe has endeavoured to extend the idea to cure the effects of induction by destroying the main cause of the disturbance—that is, by reducing the sudden rise and fall of the prime telegraphic currents; but to do this means to retard telegraphy, and

we cannot afford in England to cripple the one system in order to benefit the other.

I have recently tried an extremely interesting experiment between this place (Southampton) and the Isle of Wight, namely, *to communicate electrically across seas and channels without the aid of wires* (Fig. 6). Large metal plates were immersed in the sea at opposite ends of the Solent, namely, at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Sconce Point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through Southampton, and the Ryde and Sconce Point plates by a wire passing through Newport; the circuit was completed by the sea, and signals were passed easily so as to read by the Morse system, but speech was not practical.

The telephone is very rapidly gaining ground, and, as improvements are effected in its accessories, in its installation, and in its mode of working, its use will still further extend. In Germany it is used very extensively for telegraphic business, there being 1,280 stations worked entirely by telephones, but in England it is not possible in the numerous open shops employed as post offices to secure that privacy which the telephone requires, nor have we yet got over our early prejudices, resulting from the errors made through the inability of the instrument in its earlier form to repeat the sibilant sounds. The instruments of the present day (thanks to the improved transmitters), however, transmit "s's" perfectly.

THE MIRROR GALVANOMETER AND SCALE.

By JOHN GOTT, Member.

If a piece of plane glass is placed before and near to a galvanometer mirror, and an image obtained in the usual way with a lamp, lens, and scale, two spots will be observed as reflected on the scale, the one fainter than the other. If, now, the mirror be deflected, the second spot will be seen to move over twice the space that the brighter one moves over. This is due to a double reflection between the surface of the plane glass and the mirror.

If instead of the plane glass we substitute another galvanometer mirror, and adjust it properly, at a distance of from $\frac{1}{4}$ to $\frac{1}{2}$ an inch, it is possible to get on a scale *four* spots, the fourth traversing four times the space covered by the first and brightest spot. In other words, we can in this way magnify the motion of the galvanometer mirror *four times*.*

As a matter of course, the further we carry these repeated reflections, the fainter becomes the image of the flame.

In order to utilise this arrangement, whereby an inappreciable movement of the mirror might be rendered appreciable, I sought for a reflecting scale which would render plainly visible the faintest image.

After a variety of experiments, I found the one I am about to describe gave the best results; and my object now is mainly to draw attention to this kind of scale, because I know well, from a tolerably long experience, that its adoption will prove a boon wherever the "mirror galvanometer" is used, more especially as a speaking instrument.

This scale will give a spot which is soft, agreeable, and incomparably less fatiguing to the eye than any other, and this without any necessity for darkening the room where the apparatus is placed.

Select an ordinary toilet mirror—the clearer the glass the better; this quality can best be judged of by removing the frame and holding the glass up to the light and looking at the edge: if it has a deep blue tinge, reject it. The thinner the glass the better—one-tenth of an inch is a good thickness. The backs of some mirrors have a coating of varnish, and these are to be preferred, as less likely to have the silvering damaged by friction in handling. Cut off a strip $2\frac{1}{2}$ or 3 inches in width, and, say, 15 inches long. The surface of this is to be frosted by rubbing with a piece of glass about an inch square, supplied with fine emery powder and water: a small handle may be cemented to this piece with Chatterton's compound.

After the frosting is completed, the strip may be framed with

* See "The Multi-Reflector," *Lumière Electrique* for 1881.

dark wood, and hinged at the back to a rod, so as to be movable around its centre, elevated or lowered, and inclined—in fact, it should have a universal motion, so that it can be adjusted to any focus.

When the scale is five or six feet from the galvanometer (the lamp with its lens being, as is usual, much nearer), the spot may be said to be equally bright at all parts of the scale.

For shorter ranges it is desirable to use a scale bent to form an arc of a circle whose centre is the galvanometer. Such a scale can be graduated by engraving on the glass; but as the frosted surface can be written upon with a fine pen and ink as readily as upon paper, any grading can be adopted, and, if necessary, be removed by washing.

Transparent scales have been some time in use: this reflecting scale possesses advantages over them which are obvious.

The necessity for darkening the room is an obstacle to the use of a mirror where it might often be profitably employed to magnify minute or feeble motions.

St. Pierre Miquelon, *August* 18*th*, 1882.

SLIPPING BUOYS FROM CABLE SHIPS.

By Frederic A. Hamilton, Associate.

In letting go buoys in submarine cable operations, it frequently happens that difficulty is experienced in consequence of the rope by which the buoy is lowered not rendering freely through its leads, so that the buoy, instead of drifting clear of the ship, is hauled alongside whilst the rope is being unrove.

This, in a seaway, is dangerous, as there is risk of the buoy being damaged, or of the flagstaff being broken, or a boat stove in.

To obviate these and other difficulties, the writer has devised a simple method of dropping buoys by means of a slip-hook or tumbler.

A, Fig. 1, shows the tumbler-hook when sustaining a weight.

The lower portion of the hook works on a hinge, as shown at B, Fig. 2, and the upper part or point fits into a slot in the shank, over which a sliding block, C, runs freely, and, on being lifted, releases the point of the hook, and with it the weight suspended.

As a precautionary measure, a pin is inserted above the slide, so that all danger of an inadvertent slip is avoided. This pin is removed when all is ready for slipping.

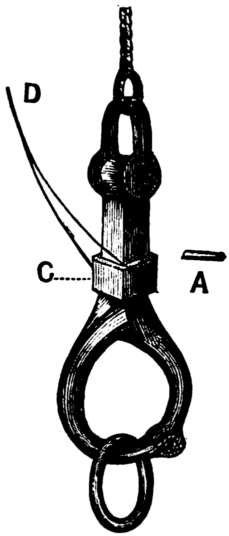


Fig. 1.

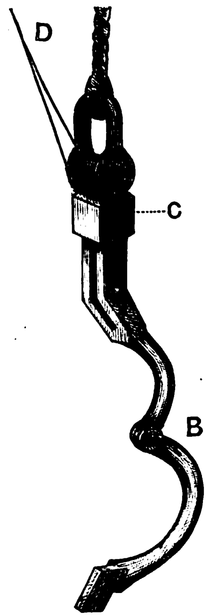


Fig. 2.

A tripping-line, D, is attached to the slide, so that, when the buoy is ready to be dropped, it is only necessary to take a turn with the tripping-line, leaving sufficient slack to admit of the buoy being lowered to within dropping distance of the water; then, on letting go the rope by which the buoy hangs, the weight of the latter will put a strain on the tripping-line, which will lift the sliding-block and release the buoy.

This method of dropping buoys has been in use on board the Anglo-American Telegraph Company's steamer "Minia" in many cable undertakings, and always with satisfactory results.

The writer is not aware of any similar means being employed in the operation mentioned, and therefore offers the foregoing remarks as likely to be of interest to his fellow-workers in submarine telegraphy.

The instrument described could be applied to various purposes, and might be found useful as a mooring-hook.

HALIFAX, N.S.,
October 27th, 1882.

ABSTRACTS.

G. GUGLIELMO—DETERMINATION OF THE ELECTRO-MOTIVE FORCE BY FUCHS' METHOD.

(*Beiblätter, Vol. VI., Part 4, pp. 295-7.*)

Taking a small cell, for example, Fuchs' method is the following:—The cell A is filled with acidulated water, into which are placed two plates, one of platinum and one of zinc. A syphon connects A with a second vessel, B, also filled with acidulated water, in which is a second zinc plate similar to the one in A. To measure the polarisation the cell, A is short-circuited, Zn_A is put to earth, and Zn_B is connected to the electrometer. The author maintains that the opening of the syphon in A must be behind the plate Zn_A, since, besides the difference of potential between Zn_A and Zn_B, the difference of potential between Zn_A and the point of immersion of the syphon must be allowed for; but when Zn_A is lifted out, the alteration in level of the liquid causes an alteration in this second difference.

In experimenting with a Daniell cell, the author made the following arrangement:—In a trough full of solution of copper sulphate he placed a copper plate, which formed a partition, on one side of which was a porous cell containing solution of zinc sulphate into which dipped a zinc wire covered up to its end with a glass tube. Into the upper part of the porous cell, and into the part of the trough behind the copper plate, dipped syphons, which were in connection with vessels of water, these in turn being put in connection by a third syphon with a beaker, B, full of solution of zinc sulphate, in which was a zinc plate, the charge of which was measured by an electrometer.

The internal resistance of the Daniell cell was measured by Mance's method, but using an electrometer instead of a galvanometer. If the resistances in the four arms of the bridge are R, R^1, r, and r^1 (internal resistance of cell), and if the electrometer is joined up to the junctions of R and R^1, and r and r^1, the short-circuit key to the junctions of r and R, and r^1 and R^1, when $R = R^1$, then $r^1 = r$. At the same time the difference of potential of the electrometer is equal to half the difference of potential of the cell, and replacing it by a standard element, its E.M.F. can be determined. The E.M.F. of the cell as found by Fuchs' method is smaller, as compared with the value found by the author's method, in proportion as the resistance of the circuit and the surface of the zinc were smaller.

O. CHWOLSON—THE EFFECT OF TENSION ON THE RESISTANCE OF COPPER AND BRASS WIRES.

(Beiblätter, Vol. VI., Part 5, p. 389.)

The wires were stretched in a metal cylinder 913 mm. high and 192 mm. diameter, filled with water. The movement of the marks was observed through glass windows. The alterations of resistance were measured with a Jacobi's rheostat. Three brass wires cut from the same piece were experimented on. The wire contained 63·66 per cent. copper, the rest being tin. In order to find the change of the specific resistance, the coefficient of elasticity, E, and the coefficient of torsion, C, were determined in kilogrammes, from which was calculated $\mu = \frac{E}{2\,C} - 1$. If S is the ratio of the relative change of resistance to the relative change of length as determined by the experiment, then $S^1 = S - (1 + 2\mu)$ is the ratio of the relative change of specific resistance to the relative charge of length. The table gives the results, r being the radius of the wire in mm., and R the resistance of a cubic mm. unstretched in arbitrary units.

r =	0·4560	0·3951	0·2313
E =	10290	10027	9845
C =	3566	3479	3408
μ =	0·4428	0·4450	0·4445
S =	2·184	2·206	2·305
S^1 =	0·298	0·316	0.413
R =	1·11	1·12	1·20

Dr. O. FRÖHLICH—EARTH CURRENTS.

(Elektrotechnische Zeitschrift, Vol. III., No. 9, p. 336, September, 1882.)

The instrument used in the observations was a modified form of Siemens' so-called "soot-writer," and the observations were made on the underground cable between Berlin and Dresden. The essential part of the apparatus is an induction coil, which is capable of motion in a constant magnetic field, the movements being traced by a fine point attached to the coil on a strip of smoked paper driven by clockwork. The zero line is drawn by a fixed point; the ordinates of the curve are proportional to the strength of the current at the corresponding moment of time; the paper travels about 117 mm. per hour.

The cable was put direct to earth at Dresden, and to earth through the "soot-writer" at Berlin. A Daniell cell introduced in the circuit gave a deflection of 5 mm. from the zero line.

Two tracings are given in the paper: one taken from 7.30 p.m. to 9.30 p.m. on July 22, a rainy, sultry day, and the second from 5.45 p.m. to 7.45 p.m. on July 26, during a thunder-storm.

In the curves are to be seen certain lengths where the point made equal excursions on either side of the datum line. These are due to the currents induced in the wire by telegraphic messages being transmitted in the neighbour-

ing wires. Besides these, however, there are sudden and greater excursions on either side, which are due to the earth's; these being especially noticeable in the second curve, taken during a storm. It was remarked that the greatest deviations occurred at the same instant as the flashes of lightning.

Dr. A. TOBLER—MEASUREMENTS WITH DYNAMO MACHINES.

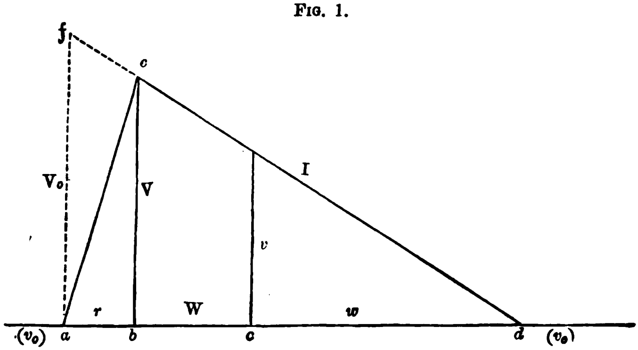
(Zeitschrift für angew. Elektricitätslehre, Vol. IV., No. 14, pp. 321-327, and No. 23, pp. 522-527.)

I. *Current and E.M.F. of a Series Dynamo.*

Let r = resistance of the helix.
W = ,, ,, magnet coils.
w = ,, ,, external circuit, including leads and one or more lamps.

In Fig. 1 the abscissæ represent resistance, and the ordinates E.M.F.

FIG. 1.



The slope of the straight line $f\ d$ represents the current, a and b are the poles of the helix, a and c those of the machine, d corresponding to a. The E.M.F. at the poles of the helix is $V—v_o$, that at the poles of the machine is $v-v_o$, V_o is the total E.M.F.

Then from the figure we have—

$$\frac{V_o - v_o}{r + W + w} = \frac{V - v_o}{W + w} = \frac{v - v_o}{W} = I \quad \ldots \quad \ldots \quad \ldots(1)$$

$$\frac{V_o - v_o}{V - v_o} = \frac{r + W + w}{W + w}; \quad \frac{V_o - v_o}{v - v_o} = \frac{r + W + w}{w}$$

$$V - v_o = \frac{r + W + w}{W + w}(V - v_o) = \frac{r + W + w}{w}(v - v_o) \quad \ldots(2)$$

$$\frac{V_o - V}{r} = \frac{V - v}{w} = I \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots(3)$$

$$\frac{V - v}{v - v_o} = \frac{W}{w}; \quad w = \frac{W(v - v_o)}{V - v} \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots(4)$$

For the total work done in the whole circuit in French H.P. we have

$$T = \frac{I^2 (r + W + w)}{9{\cdot}81 \div 75} = \frac{V_o \ I}{9{\cdot}81 + 75} \quad \dots \quad \dots \quad \dots \quad \dots (5a)$$

in place of which we may write

$$T = \frac{\{I (r + W) + (v - v_o)\} I}{9{\cdot}81 \times 75} \quad \dots \quad \dots \quad \dots \quad \dots \quad (5b)$$

since from ① $v - v_o = I\,w$.

The energy absorbed in the machine is

$$t_1 = I^2 (r + W)$$

and in the outer circuit it is

$$t_2 = I^2 w.$$

II. *Current and E.M.F. in a Shunt Dynamo.*

Fig. 2.

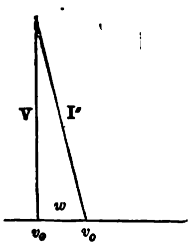


Fig. 3.

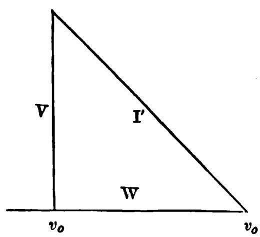
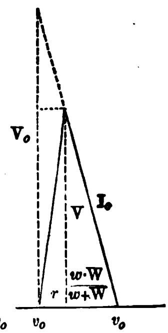


Fig. 4.



Figs. 2, 3, and 4 represent the several quantities in the magnet coils, in the outer circuit, and in the helix respectively.

The letters having the same meaning as in case (I), it follows—

$$\frac{V - v_o}{W} = I', \ \frac{V - v_o}{w} = I''$$

$$I' + I'' = I_o \, ; \ \frac{V_o - V}{r} = I_o$$

$$V_o = I_o\, r + V$$

The compound resistance of magnet coils and of external circuit is of course $\frac{w \cdot W}{w + W}$. If this value is set off as in Fig. 4, the values of I_o and V_o are obtained.

The total work is

$$T = \frac{(V_o - v_o) I_o}{9{\cdot}81 \times 75} = \frac{I_o^2 \left(r + \frac{w \cdot W}{w + W} \right)}{9{\cdot}81 \times 75} \text{ H.P. (French).}$$

Work in helix $t = \frac{I_o^2 r}{9 \cdot 81 \times 75}$ H.P.

Work in magnet coils $t_1 = \frac{I'^2 W}{9 \cdot 81 \times 75} = \frac{I' (V - v)}{9 \cdot 81 \times 75}$ H.P.

Work in outer circuit $t_2 = \frac{I'^2 W}{9 \cdot 81 \times 75} = \frac{I' (V - v)}{9 \cdot 81 \times 75}$ H.P

The efficiency of a shunt dynamo is

$$Rd = \frac{t_2}{t_1 + t_2 + t_3} \text{ or}$$

$$Rd = \frac{(V - v_o) I'}{I'_2 r + (V - v_o) I' + (I_o - I')^2 w.}$$

III. *Transmission of Power.*

Fig. 6.

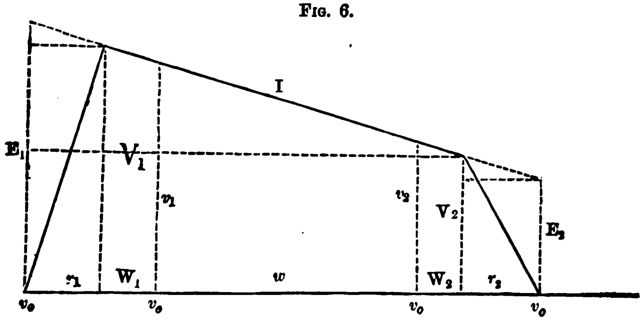


Fig. 6 shows the diagram representing the current and E.M.F. in this case. The letters have the same meaning as before, those marked 1 referring to the generator, and those marked 2 to the motor. It follows from the figure that

$$\frac{E_1 - E_2}{r_1 + W_1 + w + W_2 + r_2} = \frac{E_1 - V_1}{r_1} - \frac{V_1 - v_1}{W_1} = \frac{E_1 - v_1}{r_1 + W_1} =$$

$$\frac{v_1 - v_2}{w} = \frac{v_2 - V_2}{W_2} = \frac{v_2 - E_2}{W_2 + r_2} = I \quad \dots \quad \dots \quad \dots \quad \dots \quad (1)$$

Then the work done by the generator

$$T_1 = \frac{E_1 I}{736} = \frac{E_1 (E_1 - E_2)}{736 (r_1 + W_1 + w + W_2 + r_2)} \text{H.P.}$$

The work done by the motor

$$T_2 = \frac{E_2 I}{736} = \frac{E_2 (E_1 - E_2)}{736 (r_1 + W_1 + w + W_2 + r_2)} \text{H.P.}$$

The work done in the whole circuit

$$T_3 = \frac{I^2 (r_1 + W_1 + w + W_2 + r_2)}{736} = \frac{(E_1 - E_2)^2}{736 (r_1 + W_1 + w + W_2 + r_2} \text{H.P.}$$

The electrical efficiency $= \frac{T_2}{T_1} = \frac{E_2}{E_1}$

A. ACHARD—THE LAW OF THE EFFECTIVE MAGNETISM OF A DYNAMO.

(*L'Electricien, T. III., No.* 34, *Sept.* 1, 1882, *p.* 457.)

The author draws attention to an article originally published in the "Annales des Mines," in which he showed that for small values of the current the magnetism increases proportionally, but after a certain point it departs from this proportion and tends to a fixed value, while the current increases indefinitely. If we wish to represent M as a function of I, we may consider it as the ordinate of an equilateral hyperbola, reckoning from a line drawn parallel to the asymptotes and on the concave side, the corresponding strengths of current being represented by the abscissæ reckoned along this parallel line from the point where it meets the curve. Let $x' y' = a \mathrm{M}_o$ be the equation to the hyperbola with reference to the asymptotes O′ x' and O′ y', M_o = OA being the limit to which M tends, and a = OB being the abscissa of the point O, for which $y = \mathrm{M}_o$. If co-ordinates are transformed to the new axes Ox and Oy, the equation becomes

$$(a + x)(\mathrm{M}_o - y) = a \mathrm{M}_o$$

or

$$x y + a y - \mathrm{M}_o x = o.$$

To determine a, suppose that the ratio of M to I is known for very weak currents, and let this ratio be λ, which is the value of $\frac{d y}{d x}$ when $x = o$. Differentiating

$$\frac{d y}{d x} = \frac{a \mathrm{M}_o}{(x + a)^2}$$

and therefore when $x = o$

$$\frac{d y}{d x} = \lambda = \frac{\mathrm{M}_o}{\lambda}$$

whence

$$a = \frac{\mathrm{M}_o}{\lambda}$$

The curve is determined therefore by M_o and λ, and its equation will be

$$\lambda x y + \mathrm{M}_o y - \lambda \mathrm{M}_o x = o,$$

whence

$$y = \frac{\mathrm{M}_o \lambda x}{\mathrm{M}_o + \lambda x}.$$

The magnetism will therefore be represented as a function of I by $\frac{\mathrm{M}_o \lambda \mathrm{I}}{\mathrm{M}_o + \lambda \mathrm{I}}$. This expression may be written in the form

$$\mathrm{M} = \frac{\mathrm{I}}{\frac{1}{\lambda} + \frac{1}{\mathrm{M}_o} \times \mathrm{I}},$$

which accords with the value given by Dr. O. Fröhlich,

$$\mathrm{M} = \frac{\mathrm{I}}{a + b \mathrm{I}}.$$

(See "Abstracts," Journal, Vol. XI., No. 43, page 404.)

The author had thought that according to the results obtained by Dr. Hagenbach the more correct value would have been

$$\mathbf{M} = \frac{\mathbf{M}_o \lambda \mathbf{I}}{\mathbf{M}_o + \lambda \mathbf{I}} - \mu \mathbf{I}.$$

This would, however, merely mean that the ordinate instead of being reckoned from Ox, should be reckoned from a line Ou, which forms an angle with Ox, the tangent of which is μ.

Dr. O. Fröhlich did find that **M** diminished when the current exceeded a certain value; but for all practical limits there is no need to make the correction represented by $-\mu\mathrm{I}$.

The law expressing I as a function of $\frac{\mathrm{R}}{v}$, if the formula $\mathbf{M} = \frac{\mathbf{M}_o \lambda \mathbf{I}}{\mathbf{M}_o + \lambda \mathbf{I}} - \mu \mathbf{I}$ were adopted, would also give $\mathrm{I} = o$ for a value of $\frac{\mathrm{R}}{v}$, which would not be zero. But there would be this difference, that instead of representing a straight line, it would represent a curve slightly concave towards the axis of $\frac{v}{\mathrm{R}}$.

INDEX OF VOL. XI.

1882.

ABSTRACTS.

INDEX

TO THE

JOURNAL

OF THE

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

VOLS. I.-X.—1872-1882.

COMPILED BY

ALFRED J. FROST,
Member of Council of the Library Association of the United Kingdom,

LIBRARIAN.

London:

E. AND F. N. SPON, 46, CHARING CROSS.

New York:

446, BROOME STREET.

1882.

LONDON:
PRINTED BY M'CORQUODALE AND CO., LIMITED, CARDINGTON STREET,
HAMPSTEAD ROAD, N.W.

INDEX.

*Authors' names marked thus * signify that the paper was read at a meeting of the Society.*

C

D

E

F

H

J

K

L

M

N

O

Q

R

S

U

V

W

Z